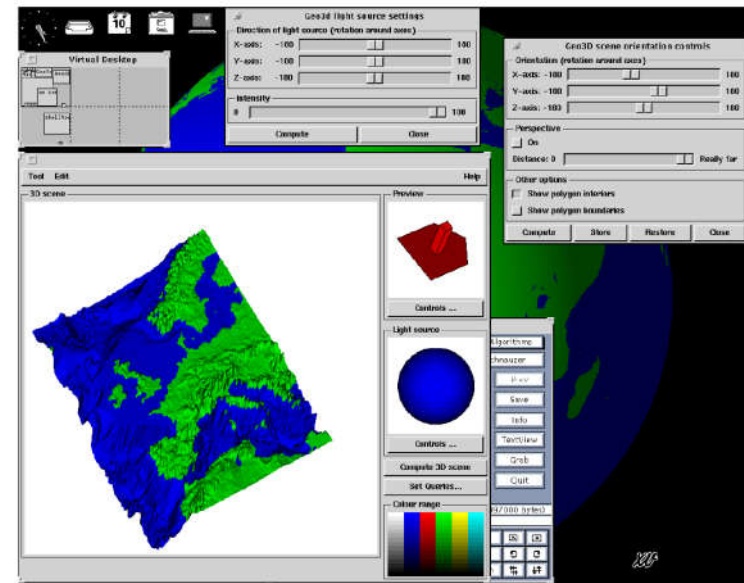


3D or not 3D - that is the question

- Dr Claire Ellul
- c.ellul@ucl.ac.uk

3D or Not 3D?

- 3D GIS has been around a while
 - At least in research
- But do we already have 3D GIS?

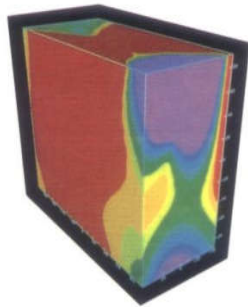


1994

VAN OOSTEROM, P, VERTEGAAL, W, VAN HEKKEN, M, 1994,
 Integrated 3D Modelling within a GIS,
Proceedings of Advanced Geographic Data Modelling (AGDM), Delft,
 The Netherlands

More History

GIS



Three Dimensional Applications in Geographic Information Systems

Edited by Jonathan Raper

Taylor & Francis
Copyrighted Material

1989

3D GIS: A Technology Whose Time Has Come

Gary Smith and Joshua Friedman

The very first output from a GIS came from a line printer attached to a large mainframe computer. The big individual letters (e.g., "W" for water) or overprinting letters, line printer geographic maps began to show the patterns and results of the first GIS analyses. In those pioneering years, 3D presentations were not viable due to the limitations of computer performance. Fast-forward 30 years and we have the ability to create dynamic, 3D presentations on laptop computers.

While it may be too early to herald the end of the plotter in favor of a virtual display, it is very clear that use of 3D GIS to visualize and analyze our GIS data is growing. Also likely to occur in the near future, 3D GIS displays are the state-of-the-art visualization tool used to present proposed developments. Figure 3 illustrates the power of 3D GIS in the visualization of a proposed new office building.

By now, we in the GIS community have learned that anyone thinking for work understand the 3D display of information. In reality, we all know better and as those that have dabbled using 3D to present their analysis can attest, a virtual environment is very conducive to public meetings. The word around is to go three-dimensional and it is our wish that presentations of GIS data should move in this direction. How many times have we looked at a zoning map forgetting that zoning also has a height component? Returning to 3D GIS need not be an arduous task. Quite the opposite to that. This article is basic primer to help one get started in the 3D arena.

Beginnings

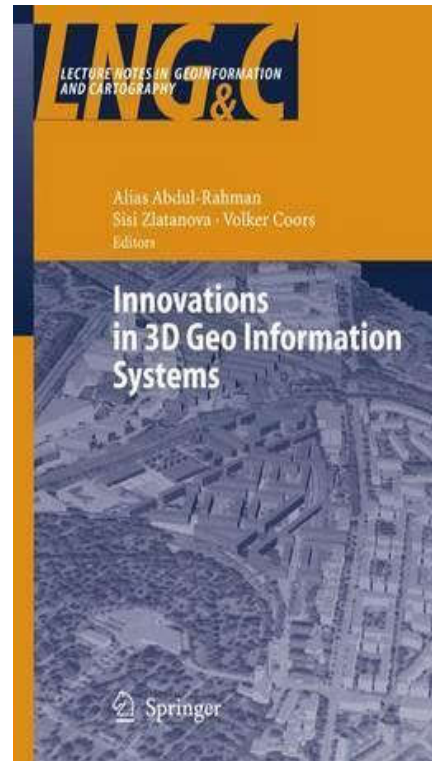
Series use of 3D in GIS started about five years ago with products like Esri's ArcView 3D Analyst product (no longer available) and Autodesk's ShapeMaker 3D extension to AutoCAD. Both of these components are principally involved in the creation of simulators and supporting software. They use their technology in GIS as a logical extension of their expertise. These and other products successfully delivered compelling 3D presentations but their acceptance by the greater GIS audience was limited. Arguably, the introduction of ArcGIS version 9 with the 3D Analyst extension has done more to fuel the growth of 3D GIS than any other software release. Almost overnight, thousands of GIS users were given



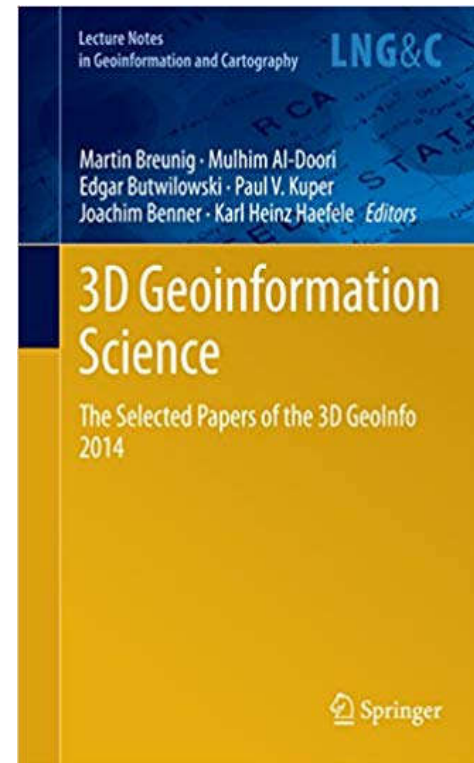
Figure 3 The original architectural drawing of a modern office building (left) and the same building rendered in a 3D GIS display (right) with the surrounding terrain from a digital elevation model in the background. Note that the look and white architectural style has been retained, updated, and draped over the terrain model. Unlike the drawing, the 3D presentation can be viewed from any location in the scene.

Stewart W. Fisher • Earth Observation Magazine • November 2004 • www.eomonline.com • Dr. Barry Roberts

2004



2006



2014

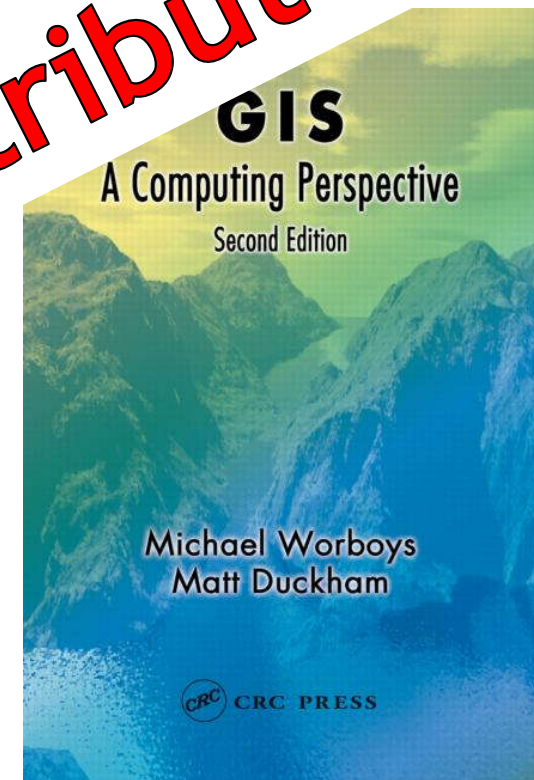
Overview

- What is 3D GIS?
 - Does it already exist?
- Why 3D GIS?
- Is there a Killer App ..?

What is (3D) GIS?

- Worboys and Duckham (2004) define a GIS as a "computer-based information system that captures storage, retrieval, sharing, manipulation, analysis, and presentation of geographically referenced data".

Geometry + Attributes

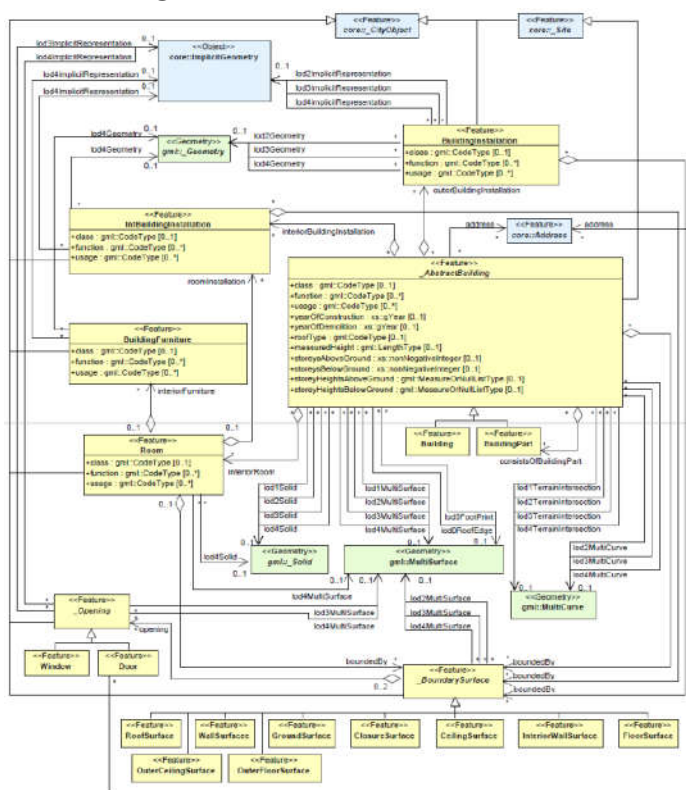


What is (3D) GIS?

- Let's assume (for now) that 3D GIS should look like 2D GIS
 - Capture and Modelling
 - Storage, Retrieval and Sharing
 - Manipulation (Editing)
 - Analysis
 - Presentation

Capture and Modelling - CityGML

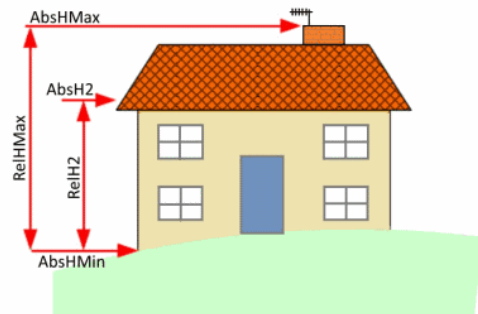
Building Model



https://www.researchgate.net/profile/Siddique_Baig/publication/272565062/figure/fig11/AS:294730651979788@1447280671650/UML-diagram-of-CityGMLs-building-model-Prefixes-are-used-to.png

<http://filip.biljecki.com/phd.html>
<https://www.isprs-ann-photogramm-remote-sens-spatial-inf-sci.net/IV-4-W5/9/2017/isprs-annals-IV-4-W5-9-2017.pdf>

Capture and Modelling - Data Sources



Mapping

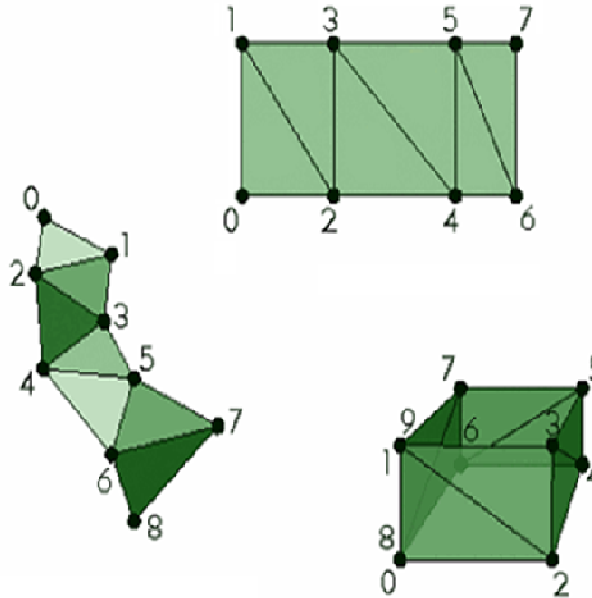
LIDAR Composite DTM - 2m

This metadata record is for Approval for Access product Afa458. Light Detection and Ranging (LIDAR) is an airborne mapping technique, which uses a laser to measure the distance between...

[HTML](#) [WMS](#)



Storage, Retrieval, Sharing



ISO X3D	Khronos glTF	OGC Community Standard cond. 3D Tiles	OGC Community Standard I3S	OGC Standard KML	Content Delivery
OGC Standard 3DPS					<p>OGC[®] Making location count.</p>



Manipulation (Editing)



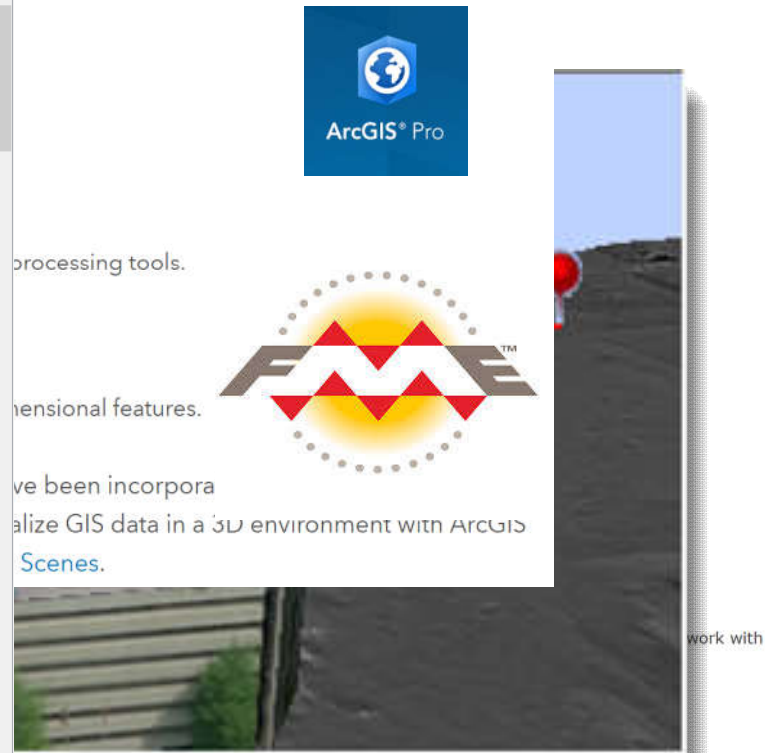
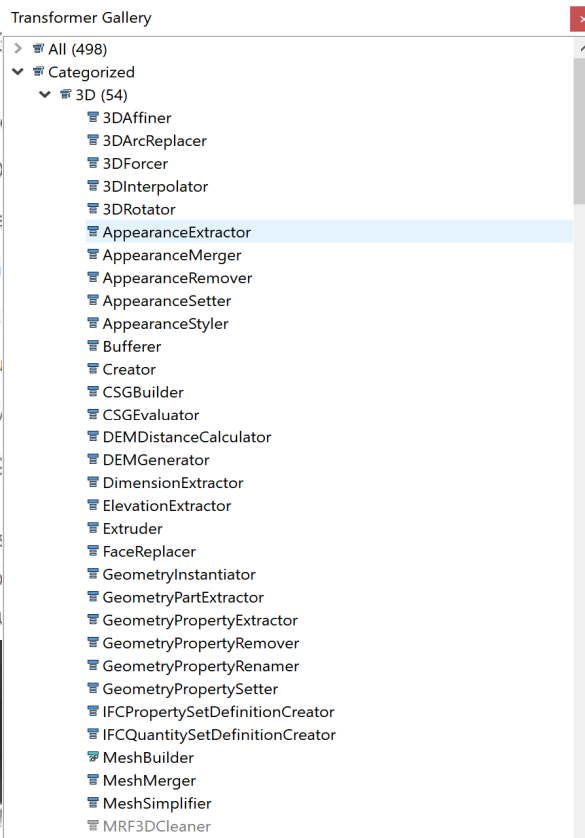
Analysis

- Box3D - Returns a BOX3D representing the maximum extents of the geometry.
- DropG
- Geome
- ST_3D
- ST_3D
- ST_3D
- ST_3D

Using ArcGIS

- Create an
- Import 3D
- Use TINs a
- Manage a
- Edit point
- Update su
- Conduct v
- Evaluate g

3D capabilities
Pro. You do no
Pro. To better u



Presentation



Presentation



DAQRI



3Dconnexion



SAMSUNG
Gear VR



HoloLens

Overview

- What is 3D GIS?
- Why 3D GIS?
 - What are the benefits of 3D over 2D?
 - Are there things that we absolutely can't do in 2D?
 - Current research
- Is there a Killer App ..?

History, Tourism, Marketing



<http://www.digitalspy.co.uk/fun/news/a393229/london-zoo-to-turn-the-gherkin-into-giant-penguin-picture.html>
http://i.telegraph.co.uk/multimedia/archive/02147/tech_ipad_2147345b.jpg

Cadastral, Planning and Land Management

BBC Claire News Sport Weather iPlayer Sounds

NEWS

Home UK World Business Politics Tech Science Health Family & Education

England Local News Regions Stoke & Staffordshire

Stoke-on-Trent house '30in too tall' risks demolition

© 10 May 2018

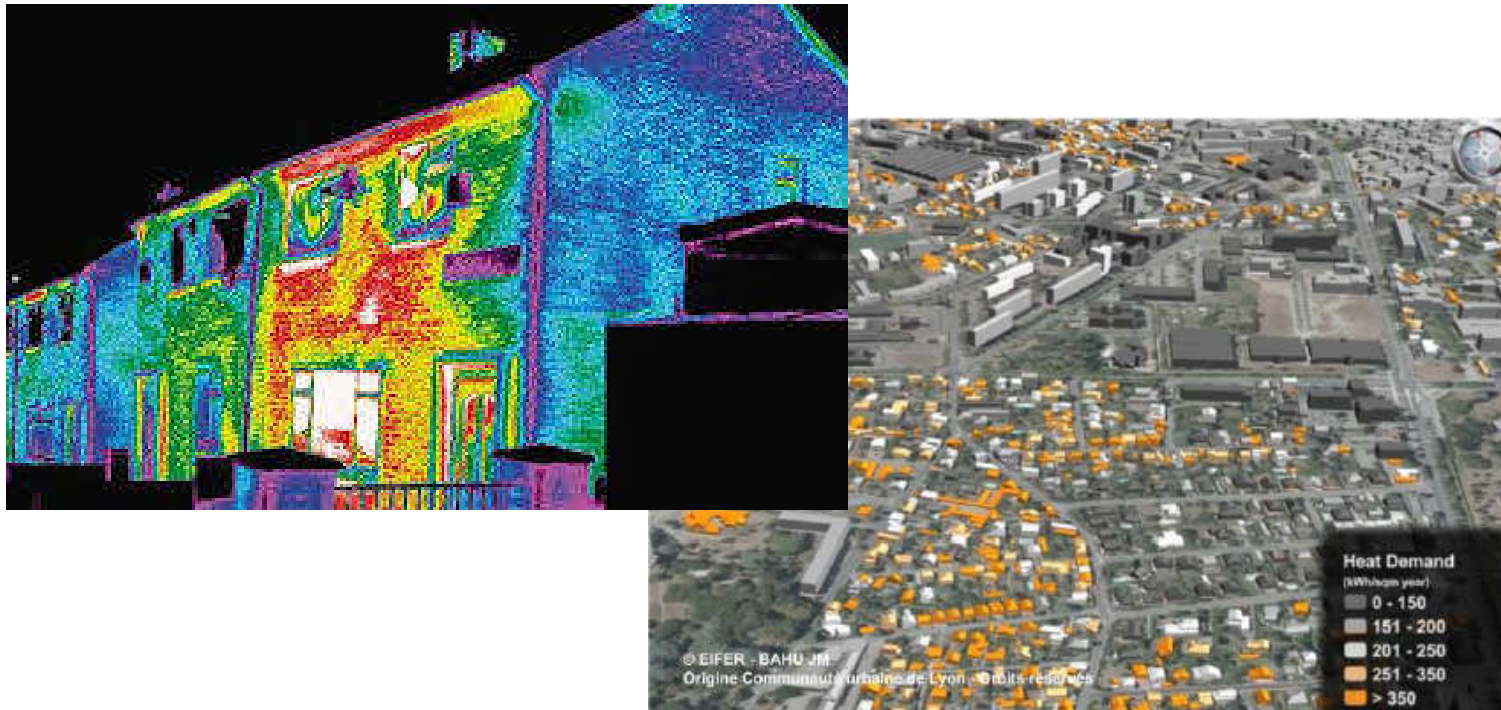
f t e Share



<https://www.dailymail.co.uk/news/article-2612073/Family-ordered-demolish-dream-500-000-home-builders-6ft-high-4ft-wide.html>

<https://www.bbc.co.uk/news/uk-england-stoke-staffordshire-44068562>

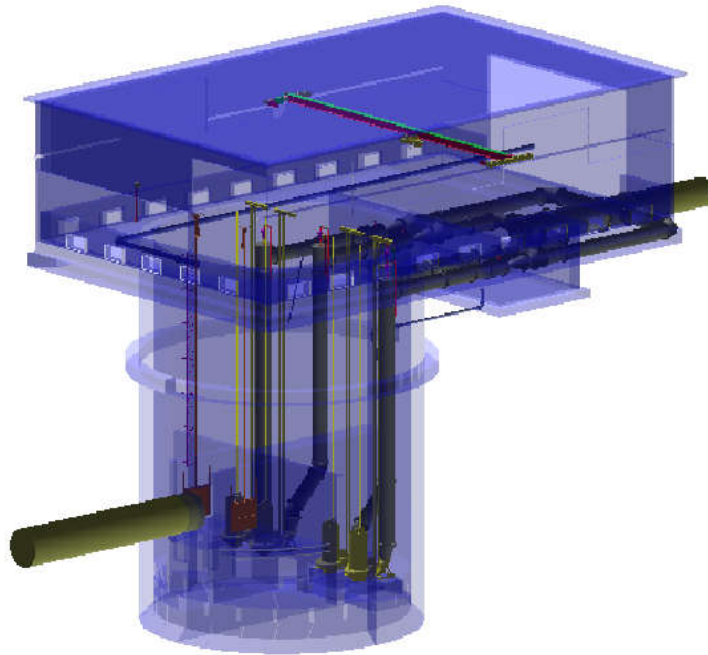
Energy



<http://www.isprs-ann-photogramm-remote-sens-spatial-inf-sci.net/II-2-W1/33/2013/isprsannals-II-2-W1-33-2013.pdf>

<http://www.theguardian.com/business/2010/apr/13/homes-fail-energy-efficiency-standards>

Infrastructure Planning and Management



<http://geospatial.blogs.com/geospatial/2013/04/spar-2013-developing-an-intelligent-3d-model-of-above-and-below-ground-infrastructure-for-the-city-o.html>

ftp://ftp2.bentley.com/dist/collateral/Web/Gallery/ch2mhill_pump_station_3.pdf

Research: What Should a National 3D Dataset Look Like?

City	Area(km ²)	Number of buildings	Roof	Façade	Interior	Textures
Adelaide	15.2	5,044	✓			✓
Austin	5.9	156	✓			
Berlin	890.0	~550,000	✓	✓	✓	✓
Boston	232.1	92,000+	✓			
Brussels	161.4	254,322	✓			
Cambridge	23.3	16,302	✓			
Central Geelong	3.0	2,570	✓			✓
Dresden	328.0	~135,000	✓			✓
Ettenheim	0.1	194	✓	✓		
Frankfurt	250.0	~230,000	✓			✓
Fredericton	0.7	82	✓			✓
The Hague	98.1	231,837	✓			
Hamburg	750.0	374,990	✓			
Helsinki	184.5	77,231	✓			✓
Honolulu	25.0	19,500	✓			
Linz	196.0	57,844	✓			
London	1,572.0	3,397,924				
Lyon	533.7	~152,000	✓			✓
Melbourne	36.2	~21,000	✓			✓
Montreal	29.2	12,051	✓			✓
The Netherlands	41,543.0	2,982,264	✓			
New York City 1	1,053.0	1,082,015				
New York City 2	1,053.0	1,083,437	✓			
North Rhine-Westphalia	34,098.0	10,132,244	✓			
Perth	20.0	~5,100 LoD1 and LoD2; 300 LoD3	✓	✓		✓
Philadelphia	0.3	859	✓			✓
Rotterdam	330.0	181,686	✓			✓
San Francisco	146.0	177,023				
Singapore	718.0	-	✓			✓
Taipei	110.0	~220,000				✓
Thuringia	16,171.0	2,214,926 LoD1; 2,210,852 LoD2	✓			
Toronto	709.0	397,602				
Vancouver	156.0	111,052				
Washington, D.C.	177.0	467,680	✓			

- Roof geometry
- Windows & door geometry
- Texture and/or color
- Interior geometry
- 3D road geometry
- Maximum roof height
- Base of roof height
- Trees & other biomass geometry

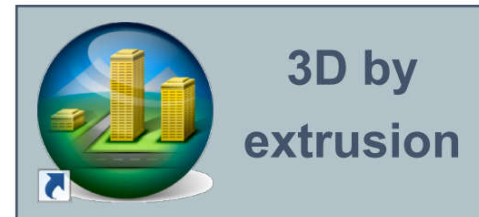


- Users perceive it as more useful than
- There is potential to be more

be more

Research: 3D Generalisation

1) Original



4) Simplified (5 m)



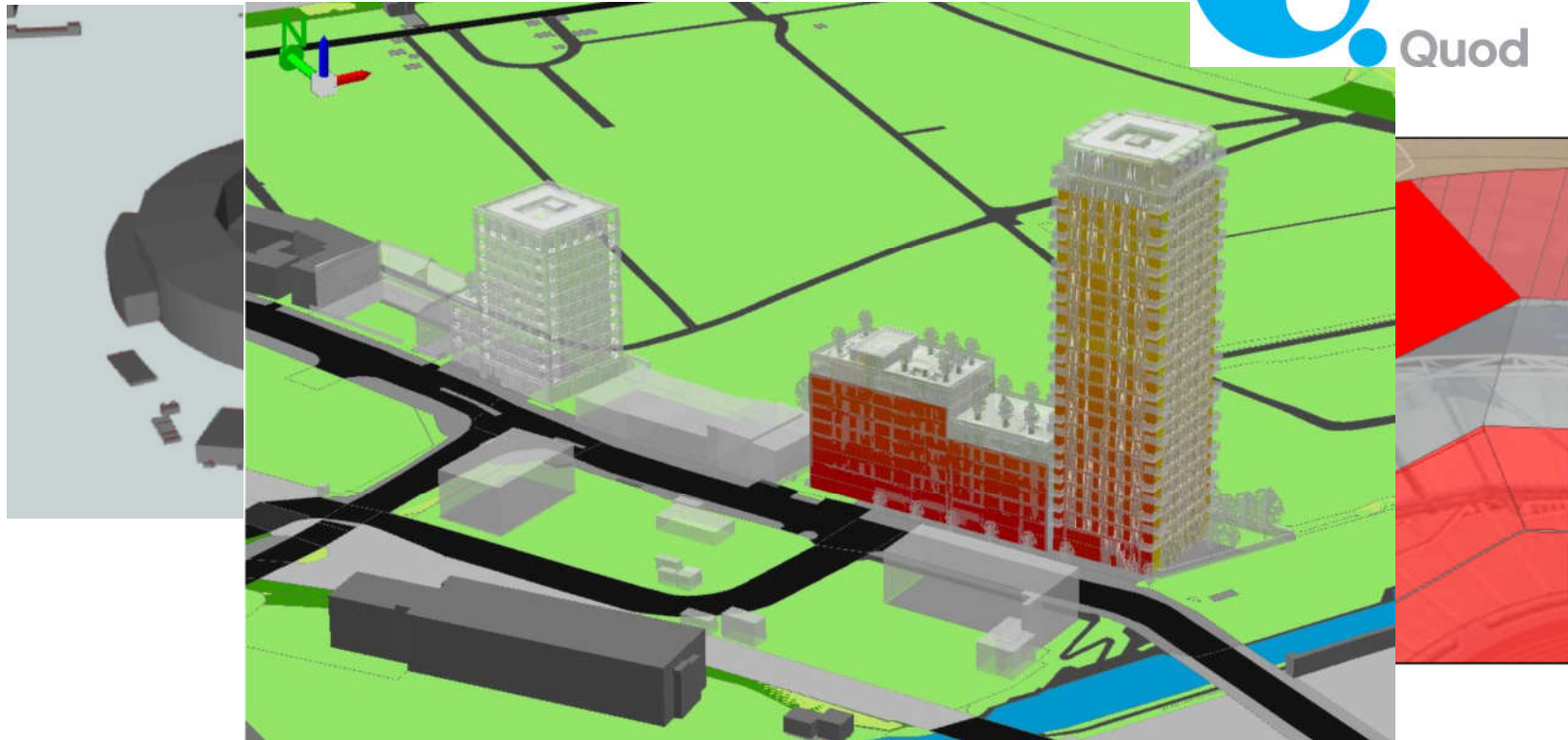
Data reduction

No. Polygons
reduced
by 81.82 %

No. Nodes
reduced
by 83.12 %

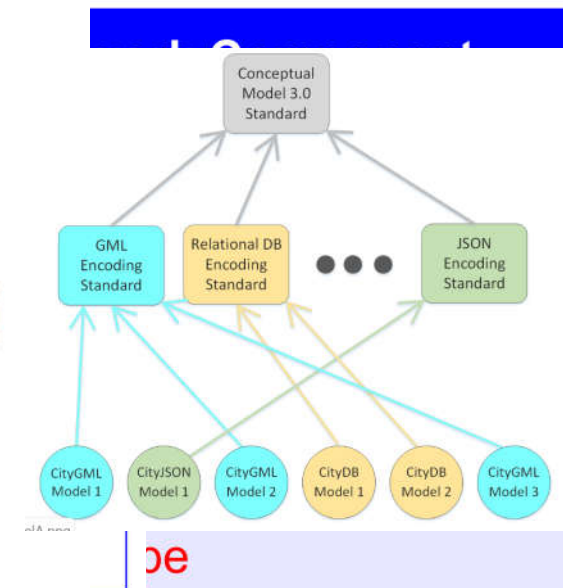
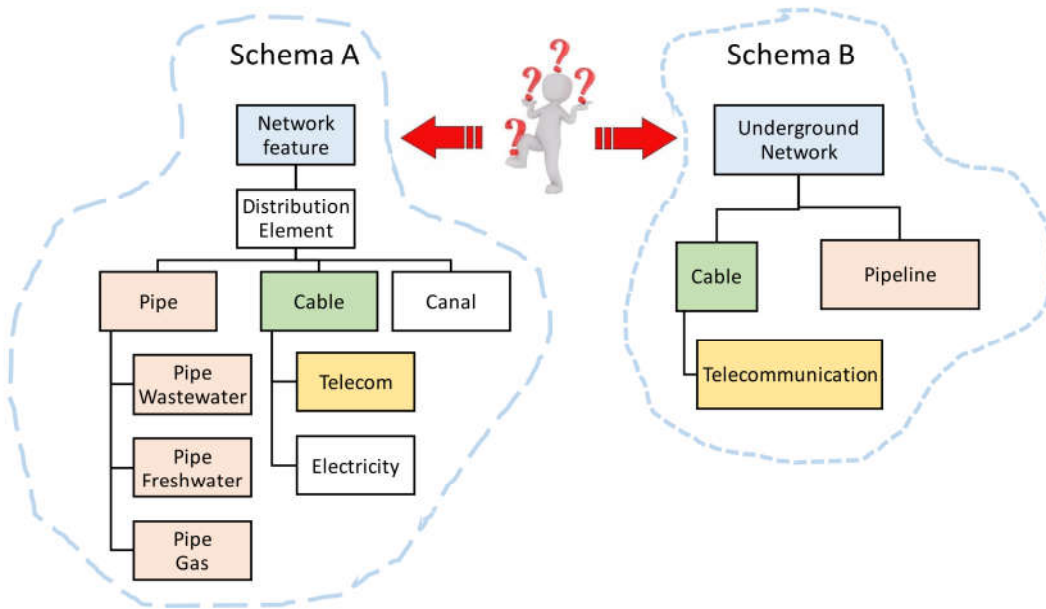
3D Volume
reduced
by 7.91 %

Research: 3D Interpolation and Visualisation



Research: Schema Modelling and Matching

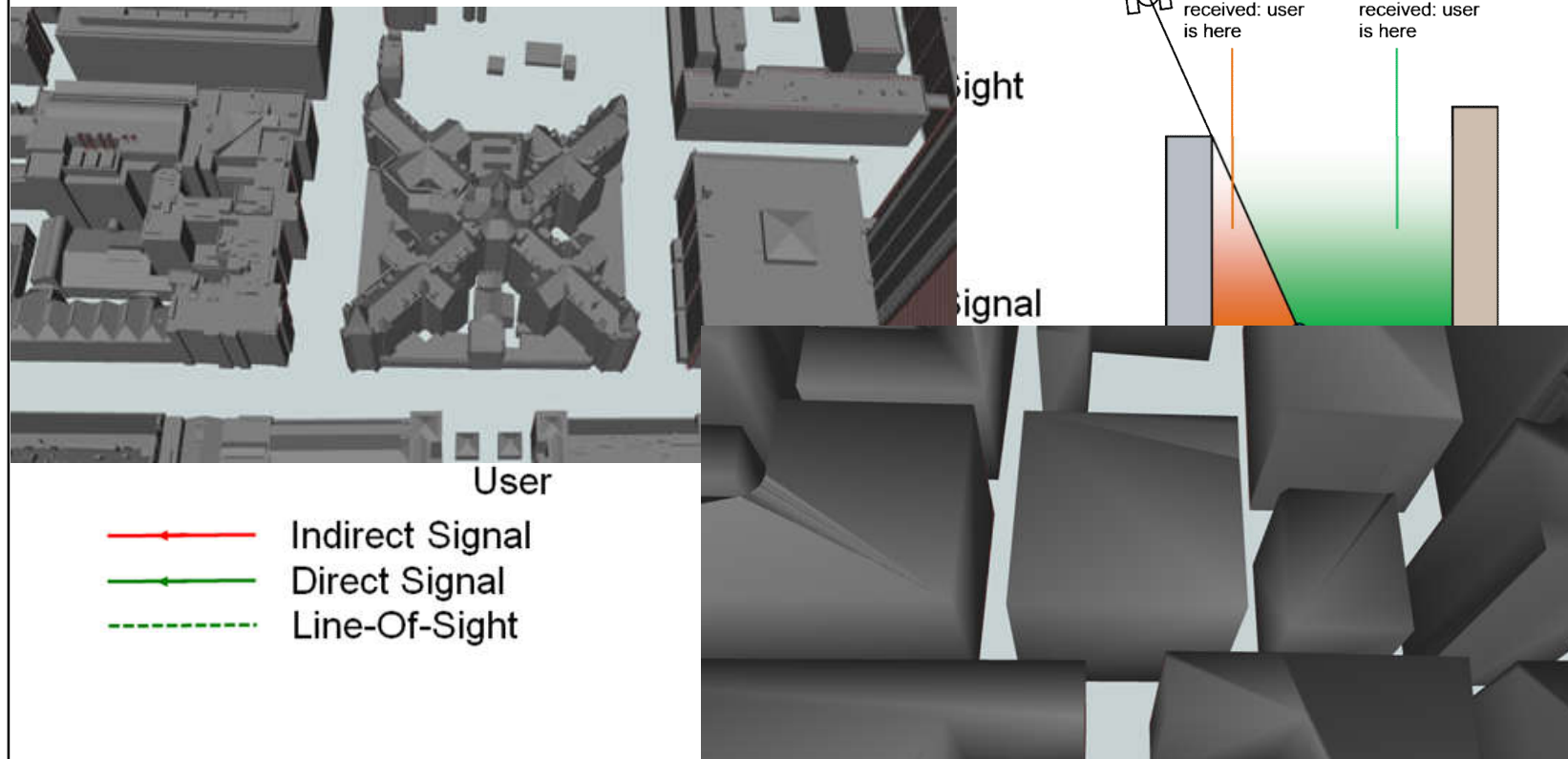
Schema matching principles



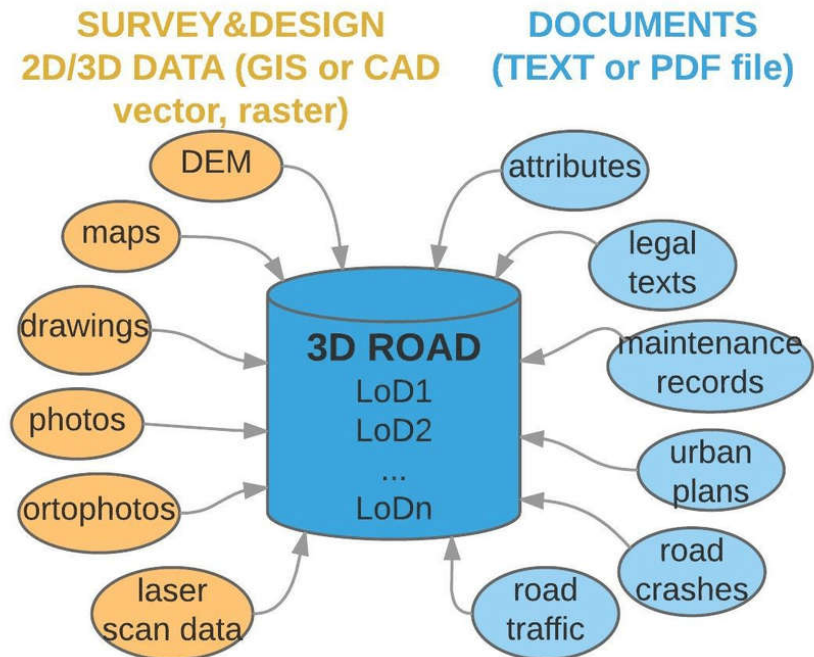
Floor_lamp (type)

ReferentType (type)

Research: Using 3D City Models to Improve GNSS



Research: 3D as a Data Index



Research: GeoBIM

BIM MATURITY LEVELS – the official version



BIM is a collaborative way of working that facilitates early supply chain involvement, underpinned by the digital technologies which unlock more efficient methods of designing, creating and maintaining our assets BIM provides a digital representation of the physical and functional characteristics of an asset to support reliable decision making and management of information during its life-cycle. At its core BIM uses 3D models and a common data environment to access and share information efficiently across the supply chain and so boost the efficiency of activities around asset delivery and operation. By helping the entire supply chain to work from a single source of information, BIM reduces the risk of error and maximises the team ability to innovate.



http://www.isprs.org/proceedings/XXXVIII/3_4-C3/Paper_GeoW09/paper26_Nagel_Stadler_Kolbe.pdf
<https://3d.bk.tudelft.nl>

<https://www.gim-international.com/news/geo-information-technology-opens-new-areas-of-bim>
<http://www.bimtaskgroup.org/wp-content/uploads/2012/06/pasdiagram.jpg>

Overview

- What is 3D GIS?
- Why 3D GIS?
- **Is there a Killer App ..?**
 - Will 3D GIS survive this time around?
 - Government policy priorities (shorter term)
 - Hype curves and technology trends (perhaps longer term)

Government Policy Priorities

Geospatial
Commission

**AGI Breakfast
Briefing Reports**



THE ASSOCIATION
FOR **GEOGRAPHIC**
INFORMATION



HM Government

**National Geospatial Strategy –
call for evidence**

August
2018

Government Policy Priorities



Government Office for Science

COUNCIL FOR

CHALLENGES AND OPPORTUNITIES FOR MODELLING THE BUILT ENVIRONMENT

The built environment consists of an array of objects that includes buildings, roads, railways, pipelines, cables, sea defences, dams, refineries, factories, power plants, water, sewage plants and wind turbines. These are increasingly complex systems that have many dependencies on, and interfaces with, other objects in the built environment.

We are highly dependent on digital representations of these assets to carry out daily business. (Such representations are sometimes referred to as 'digital models' or 'data models', though this is a specialist use of the term 'model'). These models all rely on having suitable data. For instance, when the rail industry was privatised, the rail maintenance companies inherited all the data about the rail infrastructure. Even though Railtrack owned the rail infrastructure, it had very sparse records of its assets, making it difficult to issue maintenance contracts. The Office of Rail Regulation felt obliged to make it a license condition for Railtrack to create an asset register, a most basic model of its infrastructure. Network Rail, the successor organisation to Railtrack, now has terabytes of data, updated frequently and increasingly used to model maintenance requirements.

More generally, the use of 3D models in design has made it possible to accurately visualise an asset before it is built. This offers considerable benefits in 'clash detection', ensuring that two things are not accidentally intended to occupy the same space. Although the visualisation is often thought of as the model, it is actually the underlying data that play a crucial role in the model, and the value of the data goes far beyond the visual rendering.

Historically, models of assets have been created and used for a single stage of an asset's lifecycle.

Computational Modelling:
Technological Futures

Government Policy Priorities

 Cabinet Office

Government
Construction
Strategy

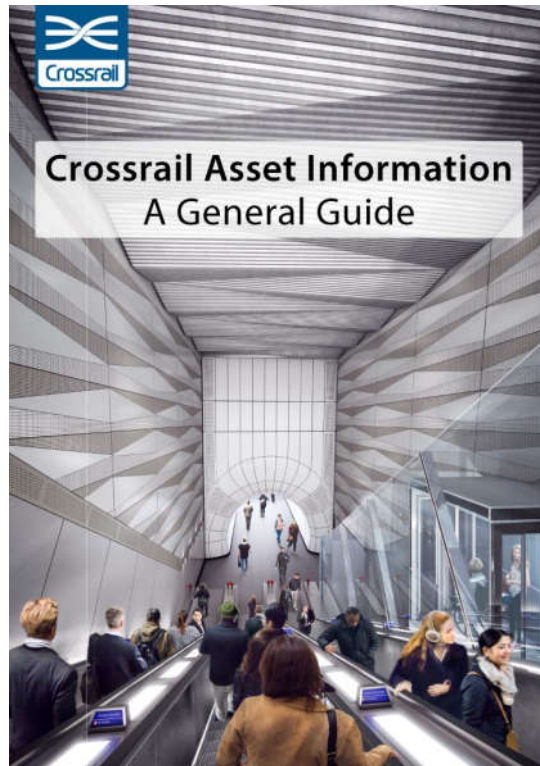
May 2011

2 Strategy Objectives

Modelling (BIM). This will be a phased process working closely with industry groups, in order to allow time for industry to prepare for the development of new standards and for training.

2.32 Government will require fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016. A staged plan will be published with mandated milestones showing measurable progress at the end of each year.

Government Policy Priorities

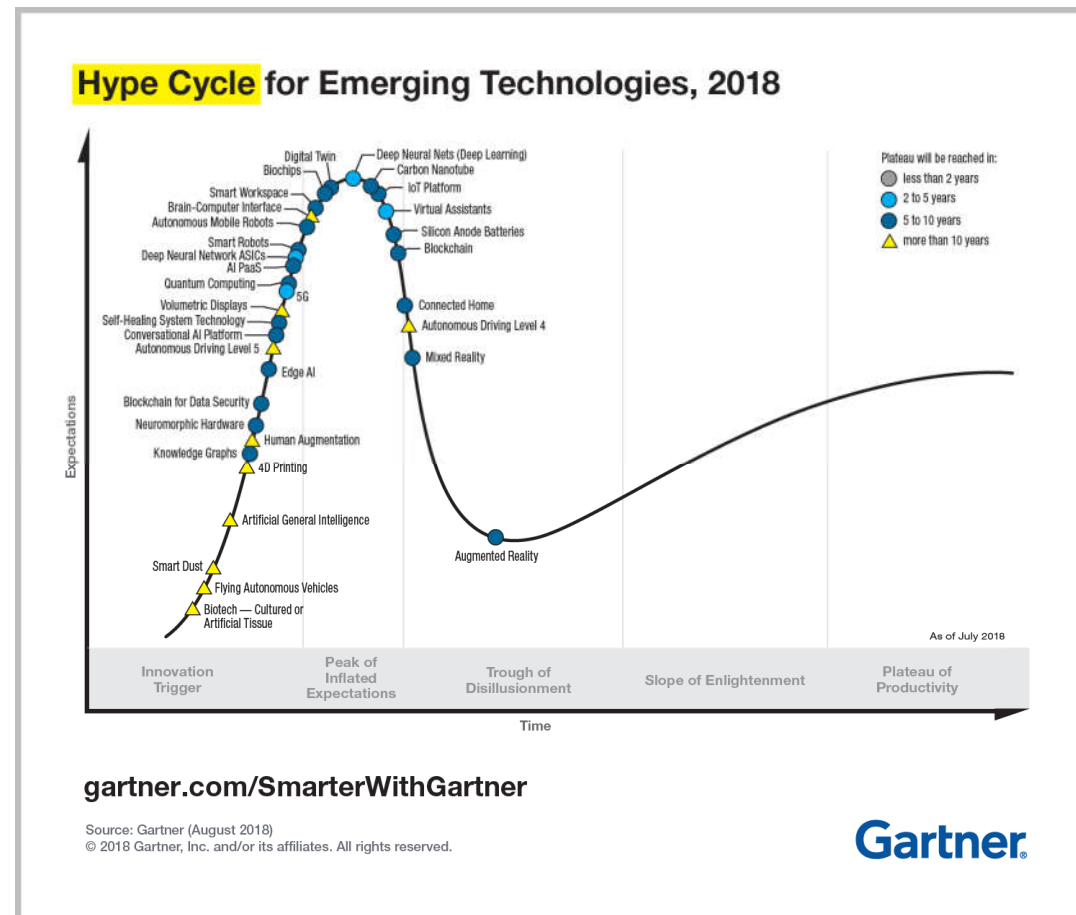


<https://learninglegacy.crossrail.co.uk/documents/crossrail-asset-information-guide/>
<http://www.stobartrail.com/item/health-safety-environment>



Hype Curves

- <https://www.gartner.com/smarterwithgartner/5-trends-emerge-in-gartner-hype-cycle-for-emerging-technologies-2018/>



Emerging Technology Trends 2018



Democratized AI

- AI PaaS
- Artificial general intelligence
- Autonomous driving Level 4
- Autonomous driving Level 5
- Autonomous mobile robots
- Conversational AI platform
- Deep neural nets
- Flying autonomous vehicles
- Smart robots
- Virtual assistants



Digitalized Ecosystems

- Blockchain
- Blockchain for data security
- Digital twin
- IoT platform
- Knowledge graphs



Do-It-Yourself Biohacking

- Biochips
- Biotech — cultured or artificial tissue
- Brain-computer interface
- Exoskeletons
- Augmented reality
- Mixed reality
- Smart fabrics



Transparently Immersive Experiences

- 4D printing
- Connected home
- Edge AI
- Self-healing system technology
- Silicon anode batteries
- Smart dust
- Smart workspace
- Volumetric displays



Ubiquitous Infrastructure

- 5G
- Carbon nanotube
- Deep neural network ASICs
- Neuromorphic hardware
- Quantum computing

gartner.com/SmarterWithGartner

Source: Gartner
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Gartner.

<https://futurecities.catapult.org.uk/2018/10/16/learning-from-city-wide-5g-demonstrators/>

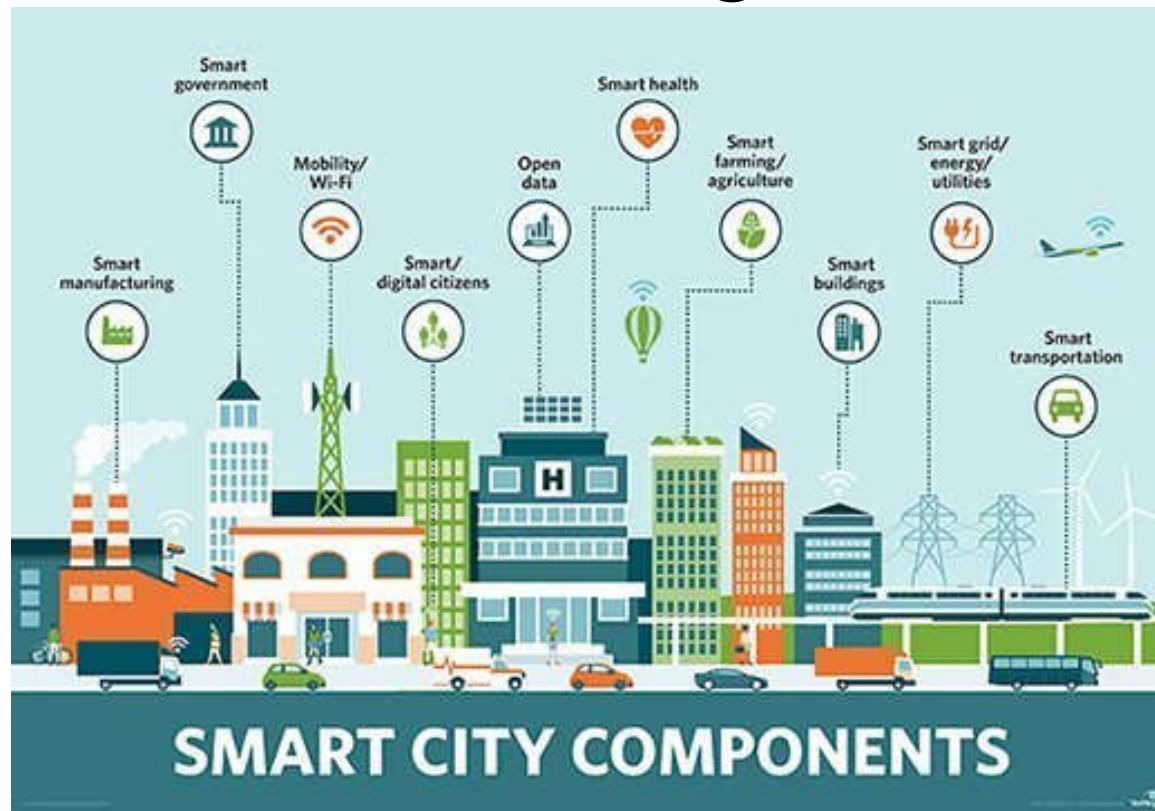
5G



More data	More devices	Instant response
<p>Improved consumer experience More connected devices Faster connection speeds</p>	<p>e-health Transport & logistics Environmental monitoring Smart energy networks</p>	<p>Vehicle-to-everything communication Drone delivery Remote control</p>

Autonomous Vehicles

Smart Cities and the Internet of Things



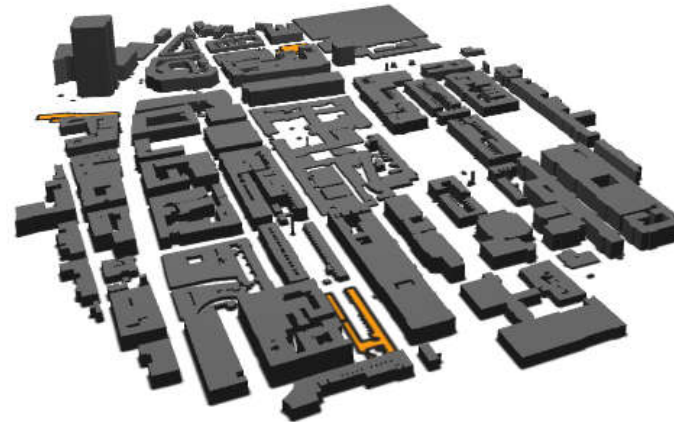
https://cdn.ttgtmedia.com/rms/onlineimages/iota-smart_city_components_mobile.jpg

Digital Twins

- https://www.youtube.com/watch?v=F_yHjILEELQ
- (video from the Netherlands)

3D or not 3D - will 3D GIS survive?

- Yes and ..
 - It will be similar to traditional 2D GIS
 - Combining geometry and information
 - Offering visualisation but also complex geospatial analysis
 - Having specialist users and non-specialists who maybe don't know they're using GIS
 - Not only about visualisation
 - Geospatial data still requires expert handling



3D or not 3D - will 3D GIS survive?

- Yes but ..
 - No one killer app - many apps!
 - It won't be similar to traditional 2D GIS
 - Web based, different interaction modes - usability?!
 - New algorithms for 3D different to 2D (interpolation, generalisation)
 - Much more 4D needed!
 - Legacy of 2D is challenging



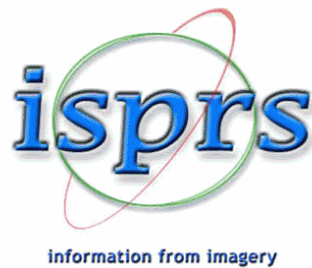
3D or not 3D? Definitely 3D!

With thanks to (in very random order!):

- Kelvin Wong
- Esti Munumer
- Paul Groves
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- Jacynthe Pouliot
- Monika Swiderska
- Jantien Stoter
- Enrica Verrucci
- Tiziana Rossetto
- Susanna Gristina
- Andrea Scianna
- Gareth Boyes

Thank You

3D or not 3D?



3D Geoinfo 2019 - Singapore - 24 -
27th September

Smart Data Smart Cities 2019 -
Malaysia - 1st - 3rd October

3D Geoinfo 2020 - UCL (end September)

Volunteers Wanted!!