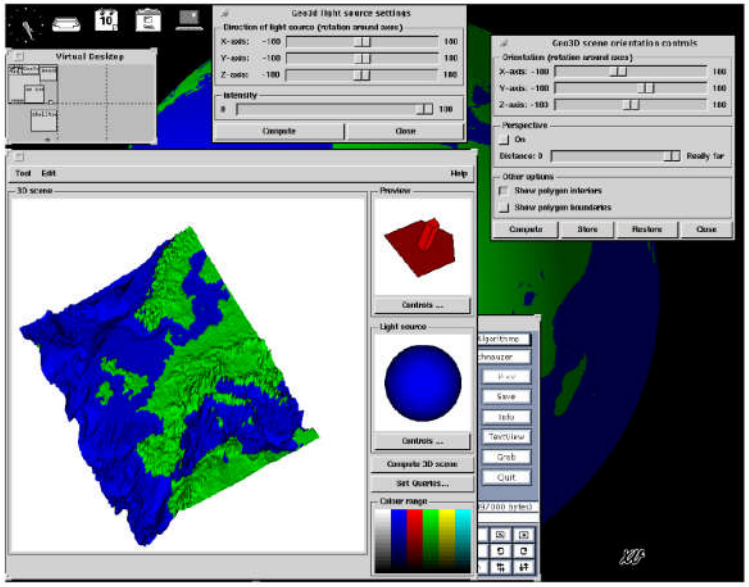
3D or not 3D – that is the question

- 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?



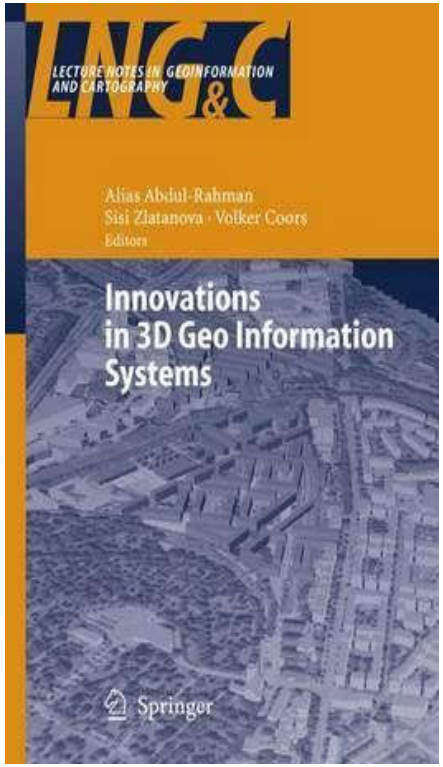
1994

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

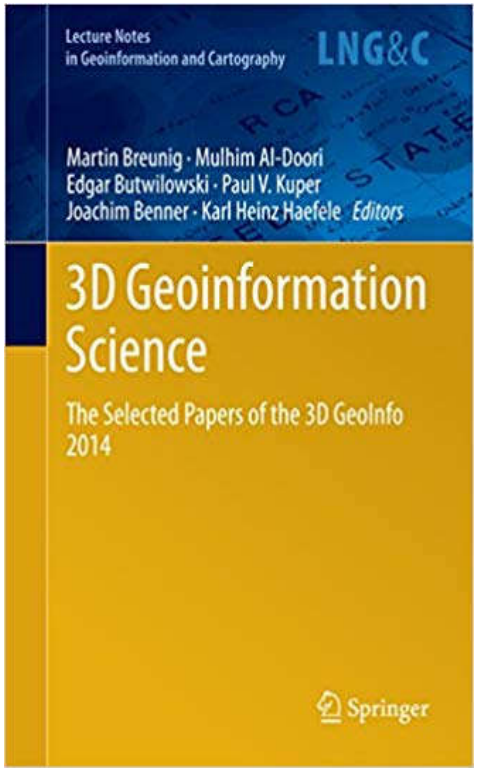
More History

1989

2004



2006



2014

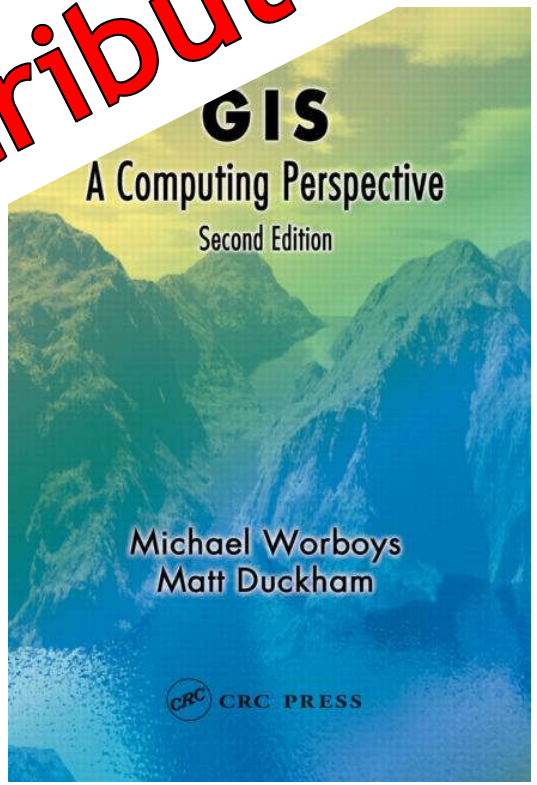
Overview

- 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 enables capture, modelling, storage, retrieval, sharing, manipulation, analysis, and presentation of geographically referenced data".

Geometry + Attributes

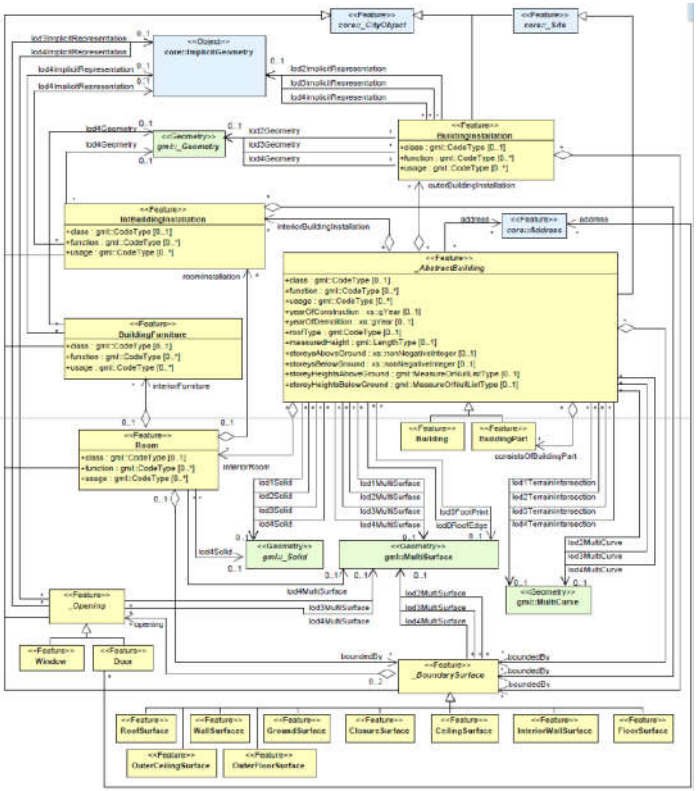


What is (3D) GIS?

- 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

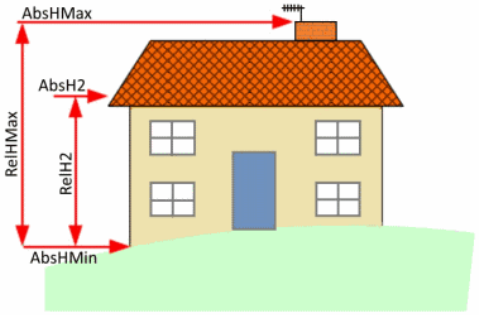
Building Model

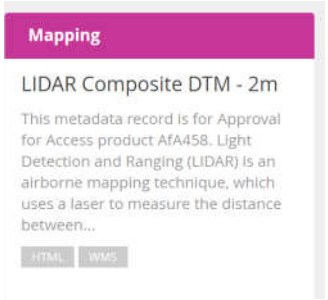


https://www.researchgate.net/profile/Siddique_Baig/publication/272565062/figure/fig11/AS:294730651979788@1447280671650/UML-diagram-of-CityGMLs-building-model-Prefixes-are-used-to.png

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





Ordnance Survey

Environment Agency

OpenStreetMap

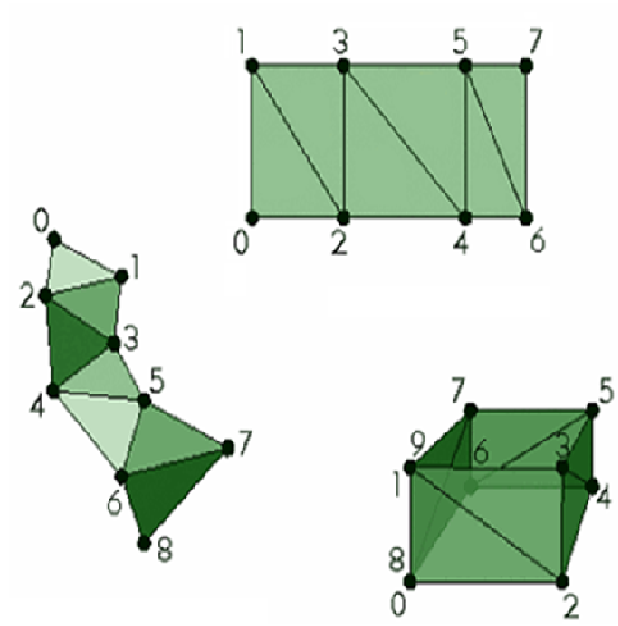
Storage, Retrieval, Sharing

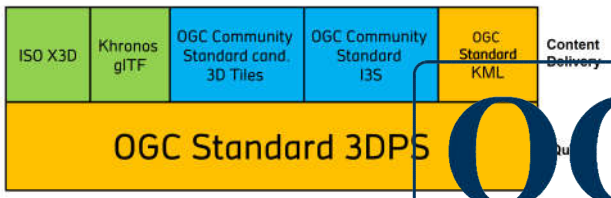
ORACLE SPATIAL

PostGIS

JSON

KML





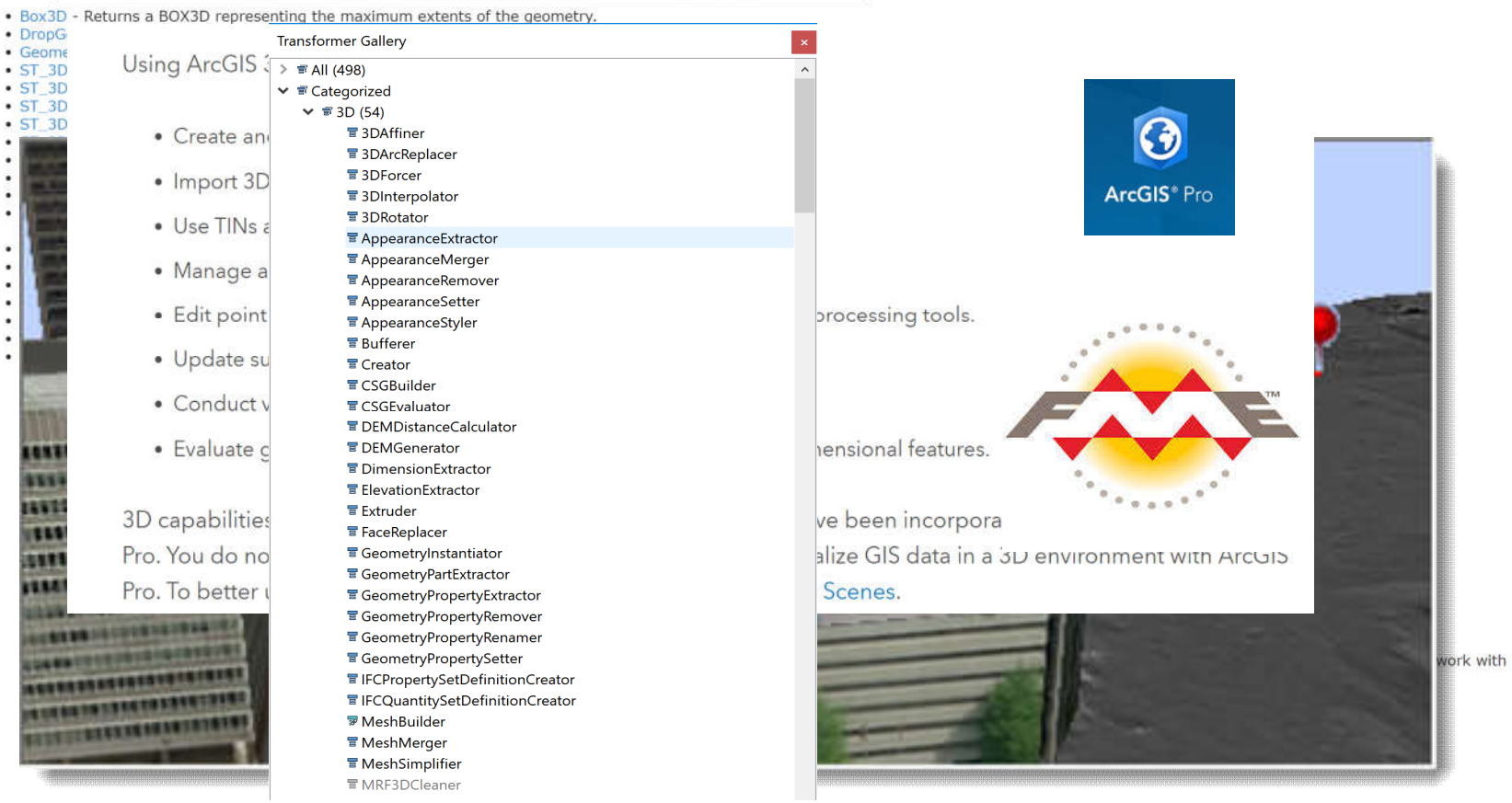
OGC®
Making location count.

FME

ESRI

Manipulation (Editing)

Analysis



http://pro.arcgis.com/en/pro-app/tool-reference/3d-analyst/GUID-87FC8AFF-91D2-45BB-9471-1E87CDD1D000-web.png

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

Cadastre, 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 Share

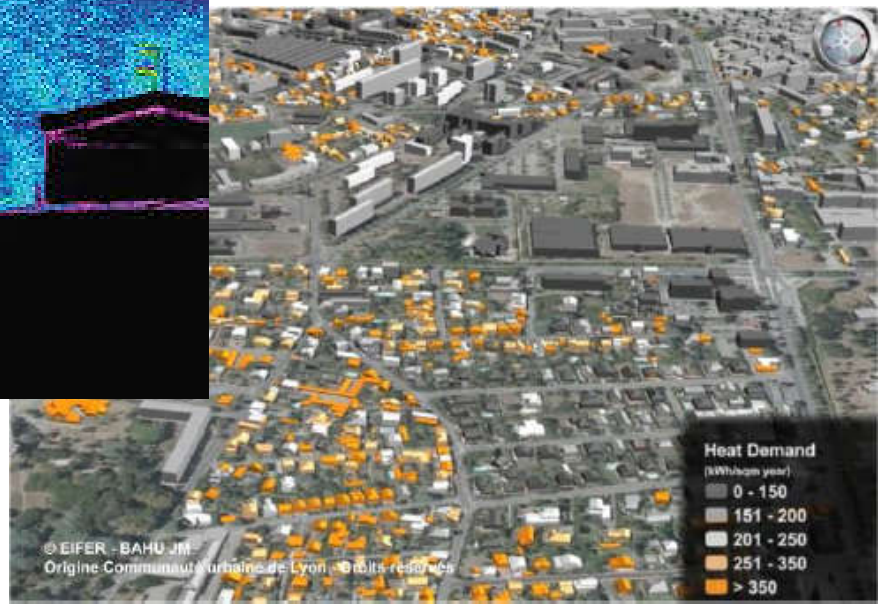
Asif Naseem moved his wife and five children into the house two months ago

The local council rejected Mr Murray's planning application because his house exceeded size guidelines

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

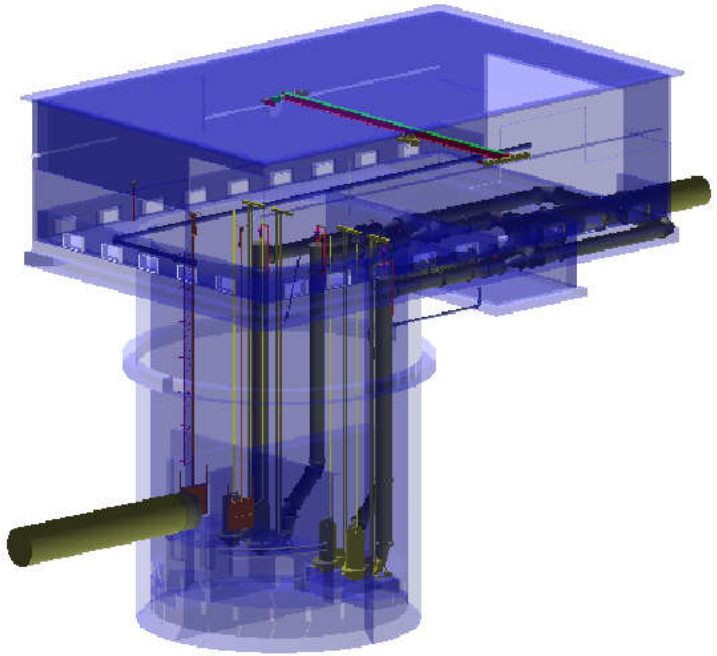
https://www.bbc.co.uk/news/uk-england-stoke-staffordshire-44068562

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(km²)	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	✓			

- Users perce … be more useful than …
- There is pot …

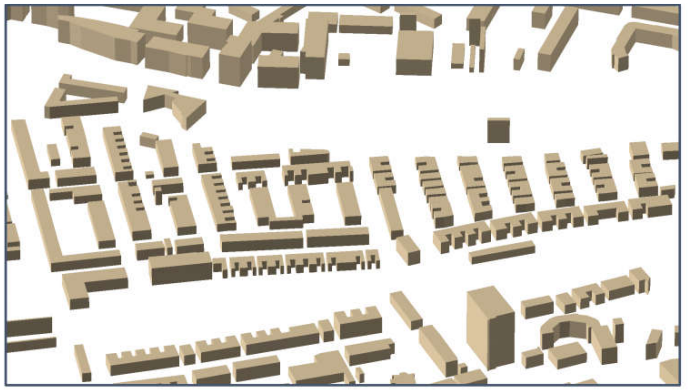
Ordnance Survey

Research: 3D Generalisation

1) Original

3D by extrusion

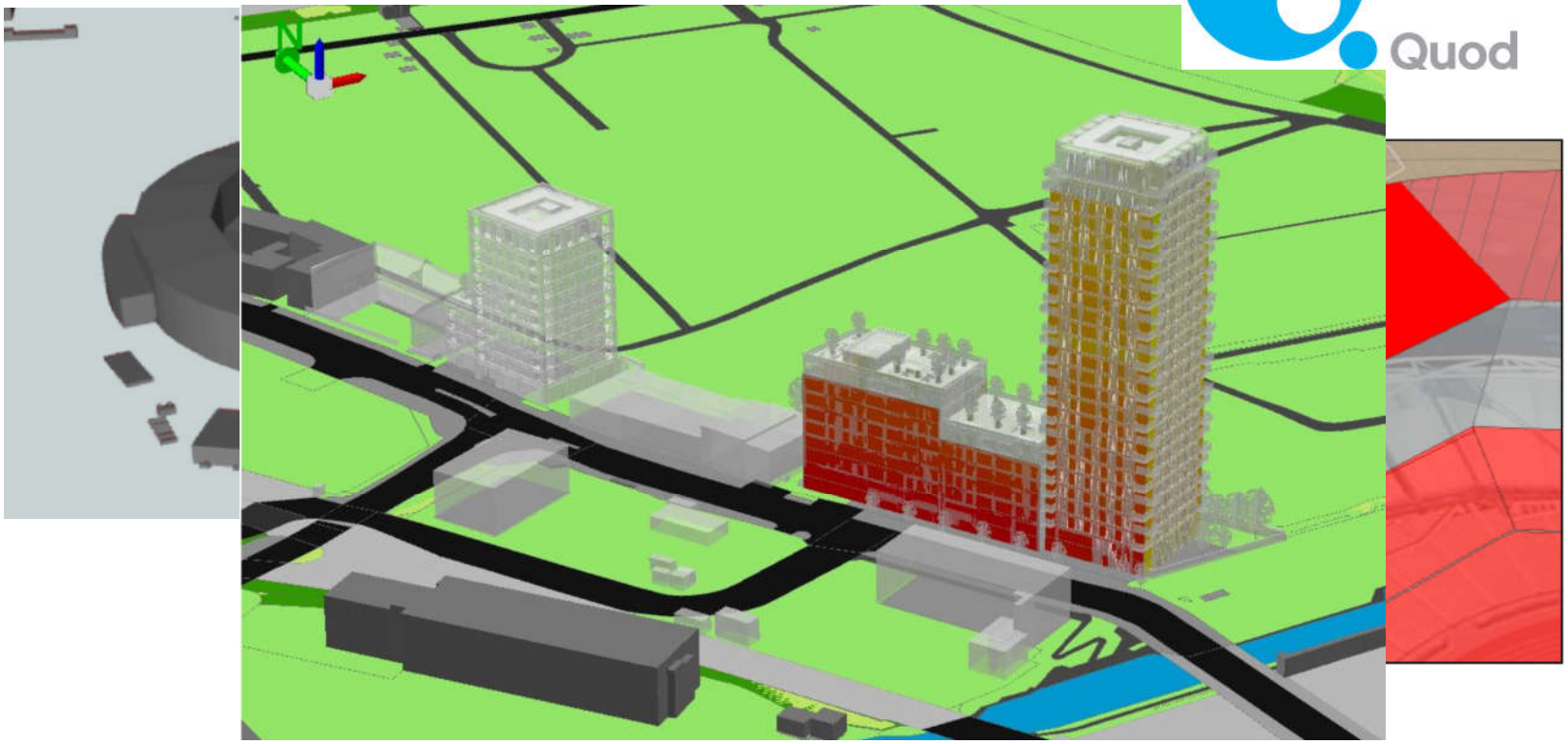
4) Simplified (5 m)



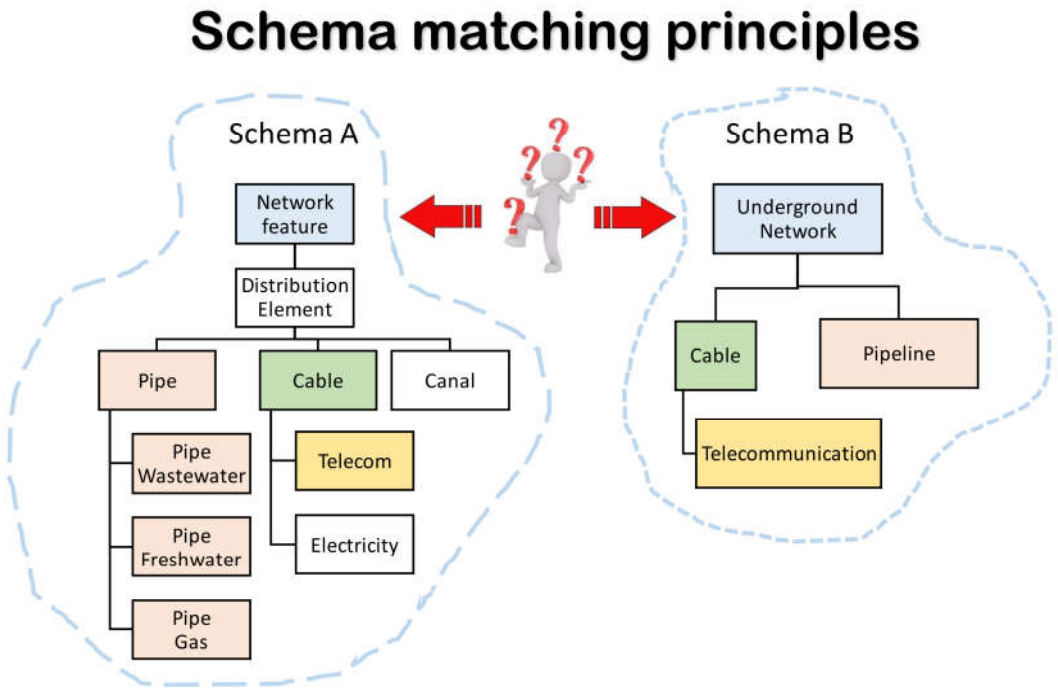
Data reduction		
No. Polygons reduced by 81.82 %	No. Nodes reduced by 83.12 %	3D Volume reduced by 7.91 %

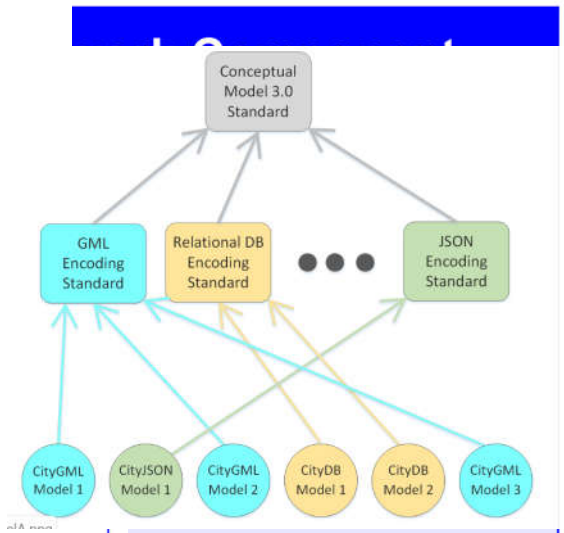
Research: 3D Interpolation and Visualisation

Quod



Research: Schema Modelling and Matching

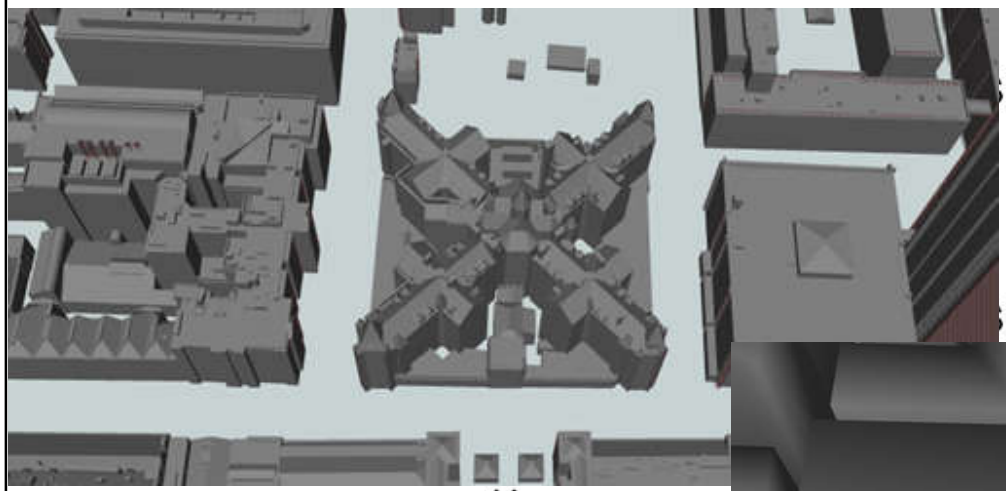




Floor_lamp (type)

ReferentType (type)

Research: Using 3D City Models to Improve GNSS



ight

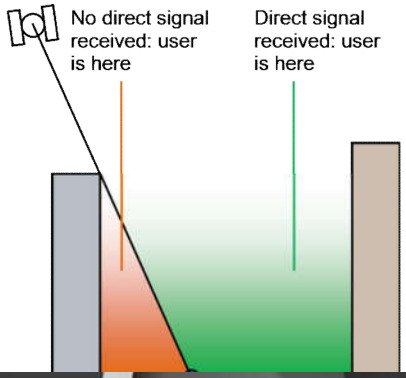
ignal

User

Indirect Signal

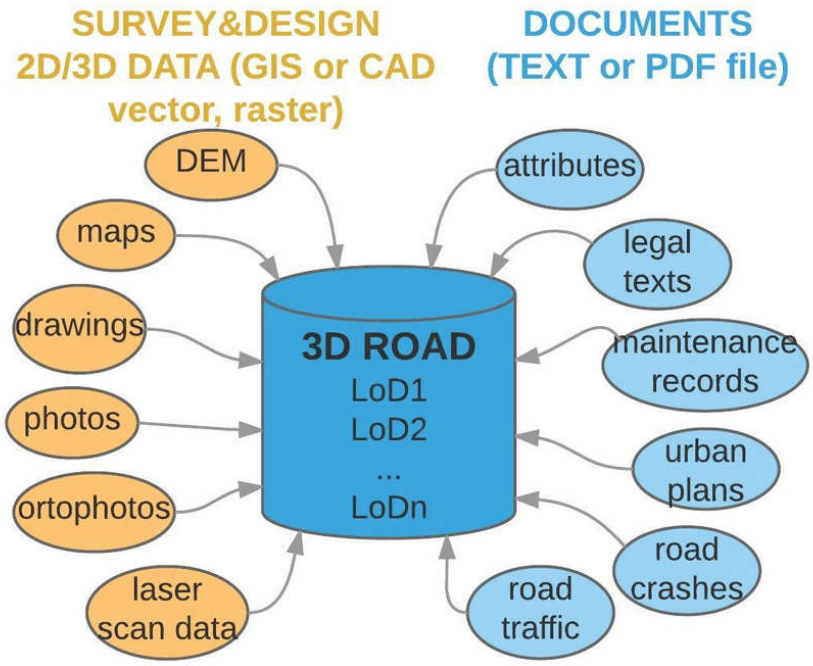
Direct Signal

Line-Of-Sight



Research: 3D as a Data Index

EEFIT
Earthquake Engineering Field Investigation Team



Research: GeoBIM

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.n

https://www.gim-international.com/content/article/geo-plus-bim-does-not-make-geobim

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

agi THE ASSOCIATION FOR GEOGRAPHIC INFORMATION

Government Policy Priorities

CHALLENGES AND OPPORTUNITIES FOR MODELLING THE BUILT ENVIRONMENT

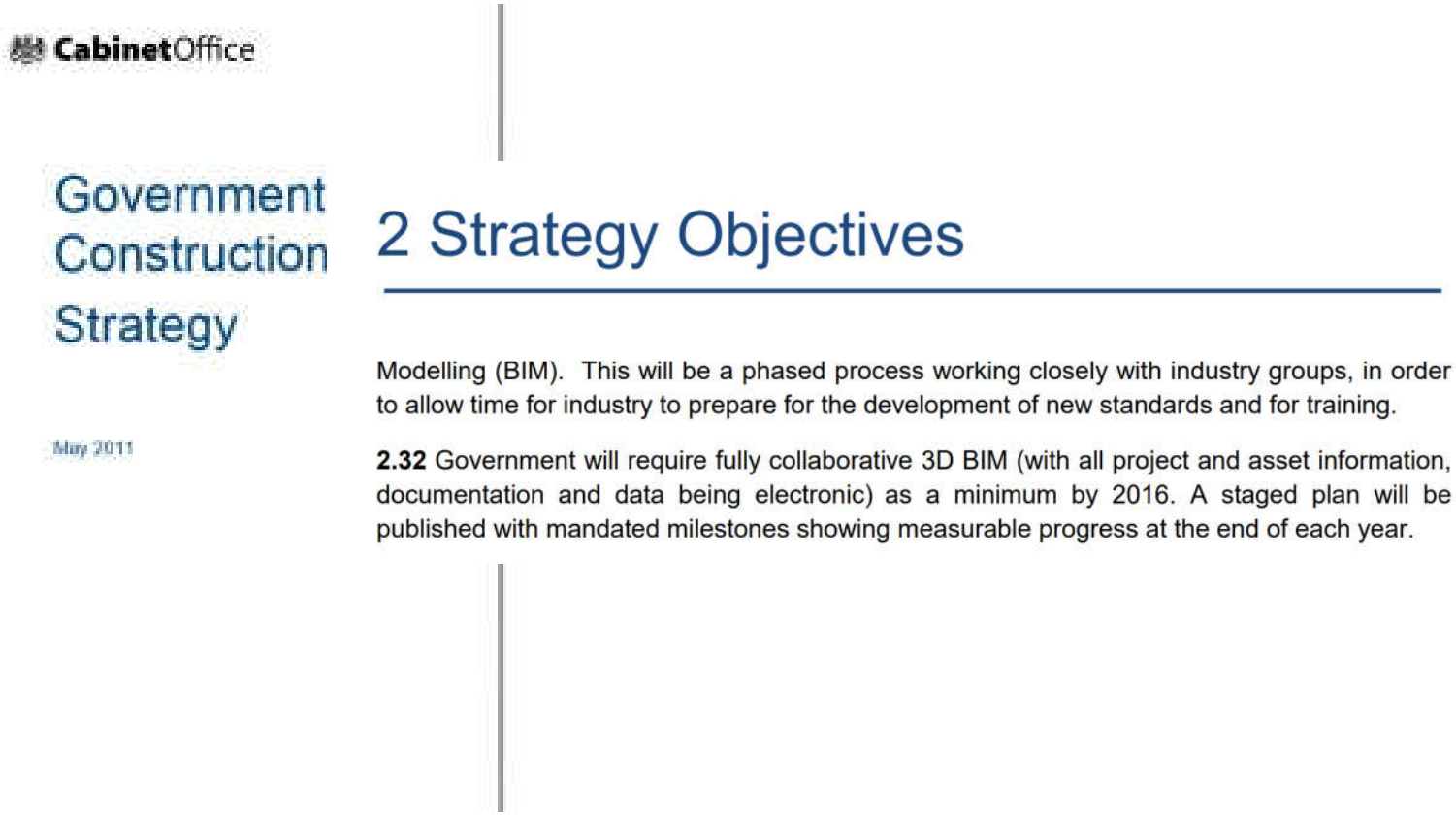
The built environment consists of an array of objects that includes buildings, roads, railways, pipelines, cables, sea defences, dams, refineries, factories, power plants, water, sewage plants and wind turbines. These are increasingly complex systems that have many dependencies on, and interfaces with,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

Government Policy Priorities



CabinetOffice

Government Construction Strategy

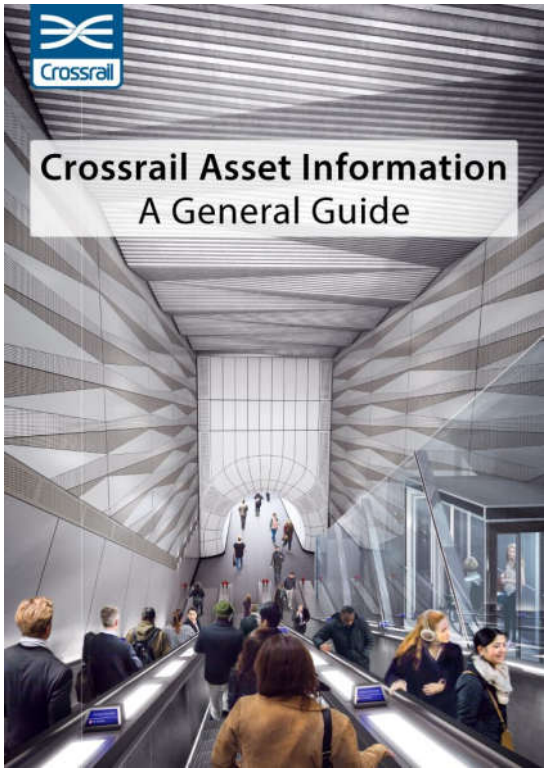
May 2011

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.

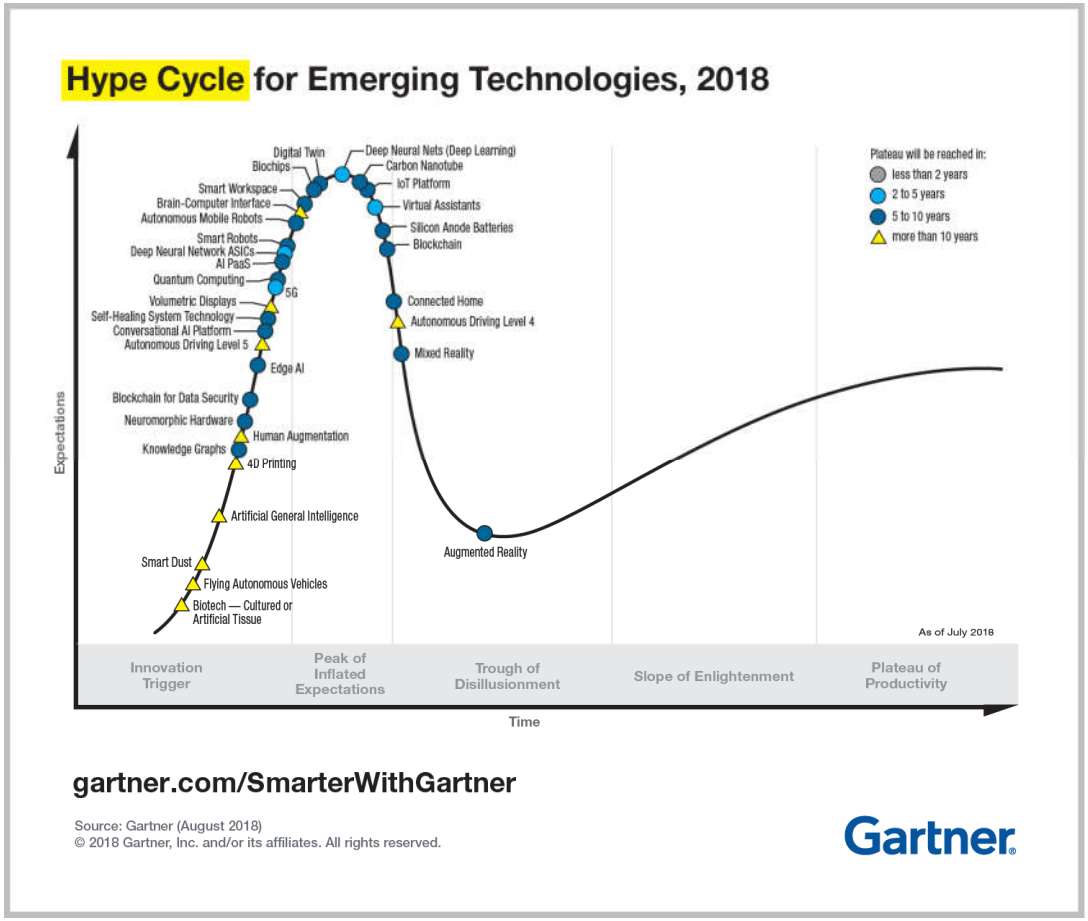
Government Policy Priorities



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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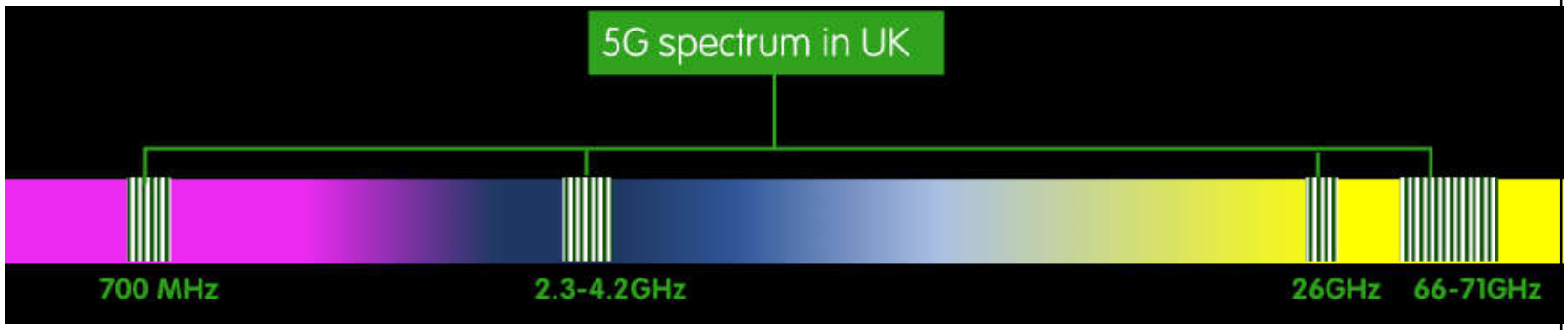
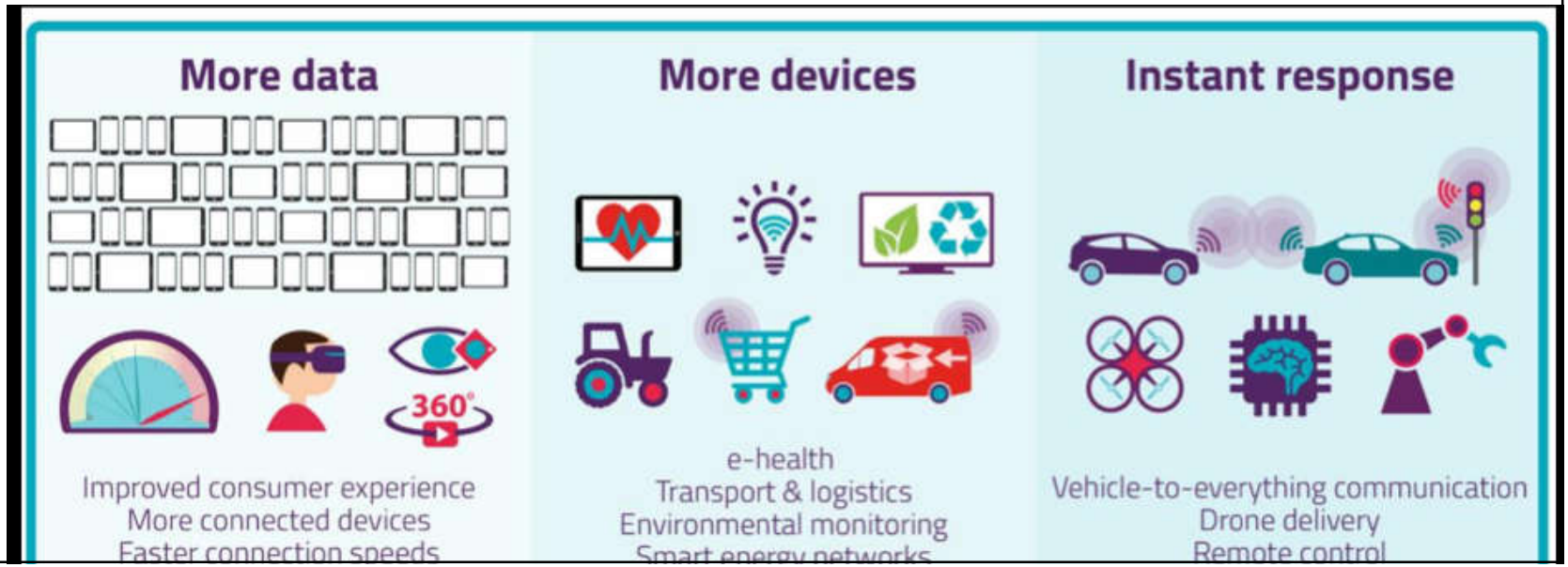
Gartner.

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

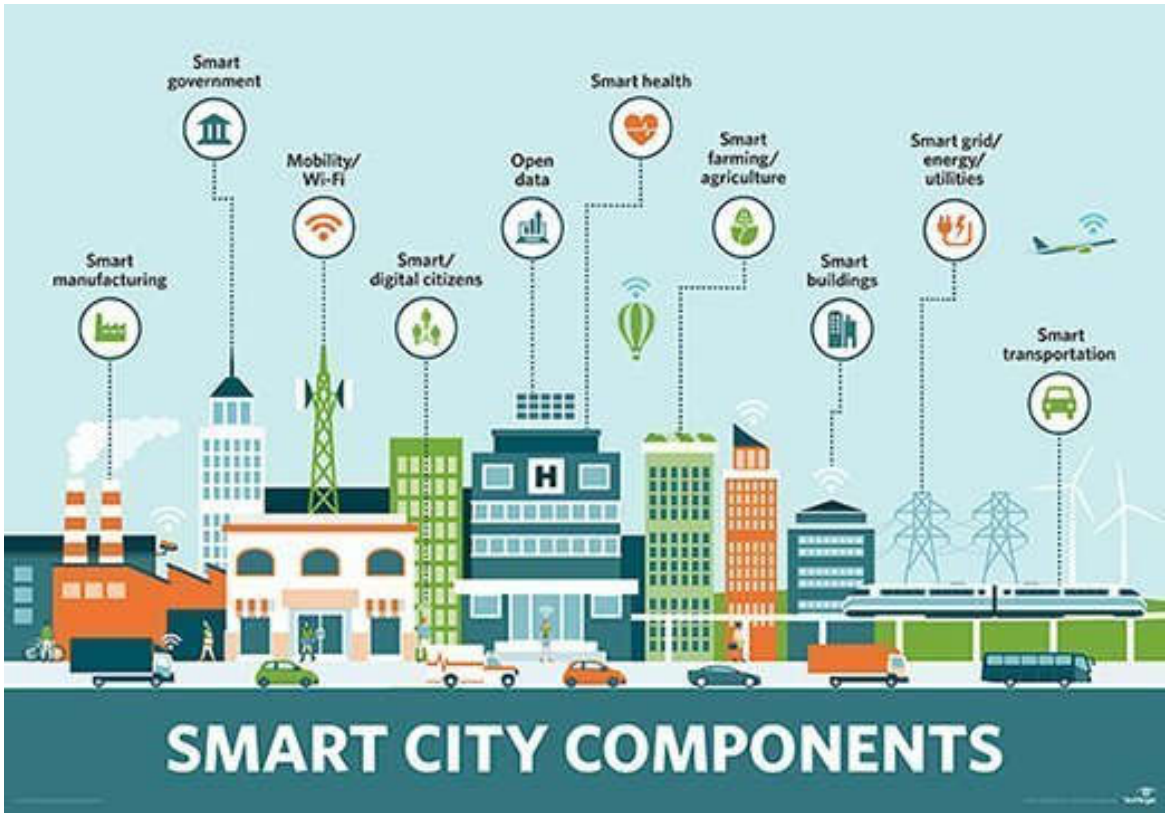
5G





Autonomous Vehicles

Smart Cities and the Internet of Things



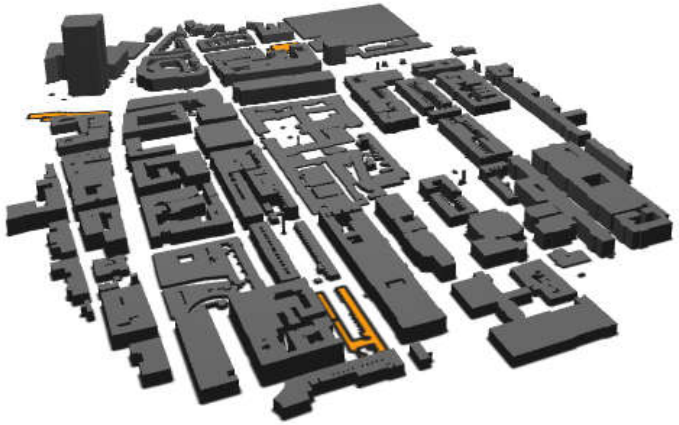
https://cdn.ttgtmedia.com/rms/onlineImages/iota-smart_city_components_mobile.jpg

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

http://www.springboardin.com/single-post/2018/08/27/Customer-Engagement-is-the-Killer-App

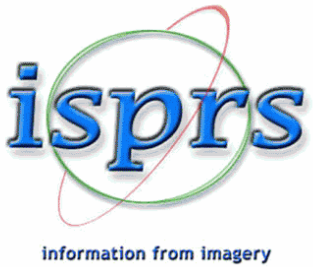
3D or not 3D? Definitely 3D!

With thanks to (in very random order!):

- Kelvin Wong
- Esti Munumer
- Paul Groves
- Mounir Adjrad
- 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!!