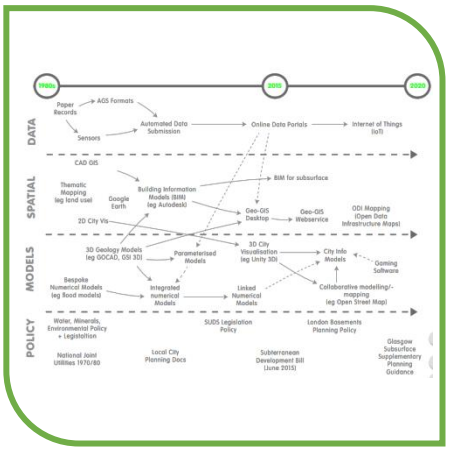
City Spatial Planning and Modelling

Hidden Depths

Workshop Report OR/16/014

S Bricker[1] and S Webb[2]

2015



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Executive Summary

There is a current drive to reform the planning system in the UK to unlock the value of data and embed digital processes into the work of government and cities. It is recognised that existing data, in particular environment and utility datasets, are not fully utilised to inform planning decisions at a local and strategic level. Failure to consider the full suite of data for cities weakens the evidence base on which planning decisions are made and leads to inefficiencies and a late stage awareness of potential issues. This situation is most pronounced for underground development in cities.

The subsurface extent of our cities is gaining increased prominence in future cities thinking. Continued urban growth, demand for resources, city resilience and sustainability concerns bring increased pressures on subsurface space, facilities and services but also opportunities for more strategic subsurface utilisation. For example it is estimated that 76% of London's total heat demand could be met by secondary sources such as ground heat and re-using waste heat from the underground. In addition we are seeing a growing trend for subsurface living – 450 applications for basements submitted to Kensington and Chelsea in 2013 alone. However we must first address the constraints, the fact that unforeseen ground risks are one of the main causes of project delays and insurance claims on completed projects at a time when government is calling for a 33% reduction in project costs. Meanwhile there are over 680,000 properties at risk of flooding from heavy rainfall in London in a 1 in 200 year event. As a result cities want to increase the amount of urban green cover and infiltration of water into the ground through sustainable drainage systems is being prioritised and included in new planning policy.

There is currently no formal policy for integrating urban underground space and above ground city services within the planning framework and no one organisation with a mandate to take ownership of this issue. However there are a number of projects and initiatives underway which are beginning to address elements of the issue, such as city data management tools, infrastructure mapping, integrated city modelling, building information modelling systems and collation of good practice demonstrators. To capitalise on these initiatives and bring the subsurface into strategic city planning the workshop, hosted by the Future Cities Catapult at their Urban Innovation Centre drew together science expertise and city innovators that work across the boundary between surface and subsurface spatial planning and use, and city modelling. The aim was to demonstrate capability and share learning, identify commercial opportunities to address the challenges, and consider how we can advance this topic at a strategic level within UK cities.

The workshop had two main objectives, which were addressed over three sessions that covered, issues and ideas, tools for city planning and use case development. Short talks by industry experts were given at the start of each session to highlight key points for the attendees.

Workshop objectives:

i) **Innovation and commercialisation**: Highlight the innovation and commercial products & services needed to address city challenges around improved city modelling and spatial planning. Identify funding mechanisms for demonstrators and pilot projects.

ii) **Policy and governance**: Review the current policy framework for spatial planning, subsurface development and management. Identify opportunities for strategic policy/city-led initiatives which tackle the challenges around spatial planning.

Session 1: The Challenge: An overview of the city challenges around spatial planning and subsurface management were presented and then discussed amongst the expert group. The issues and potential opportunities were captured during the breakout session and focussed on four challenges areas, commercial issues, technology development, people and policy and scientific knowledge. Much of the concern highlighted by attendees centred on the disparate and silo approach, whether that be relating to data, models, policy or organisational procedure. Overcoming the barrier of commercial data was discussed. The need for business models which recognise the value of data and flexible mechanisms for data delivery were put forward.

Session 2: Tools for city planning: Existing capability in city spatial planning and subsurface management was demonstrated, highlighting how real challenges such as, integrated infrastructure mapping have been tackled and the real-term benefits that resulted. A timeline of data protocols, spatial planning tools, modelling technologies and policy guidance was presented highlighting the range of tools that are available to help provide solutions to improve city planning. Attendees provided a 'future look' of emerging technology and anticipated policy change that is likely to shape city development in future. The influence of devolved governance and planning, opportunities for new subsurface planning policy, the need for open and free data platforms and the desire for linked city modelling were highlighted.

Session 3: Developing use cases: Having gained an understanding of the main challenges for city spatial planning and having reviewed the tools available to help tackle these challenges experts at the workshop co-developed ideas for tools and solutions focussed on specific use cases. Three ideas were put forward by the expert group; i) a city information modelling platform that provides decision support systems by bringing together different city datasets using interoperable software; ii) An integrated city mapping system for the collection, archiving, release and visualisation of data across the whole 3D form of the city (full height and depth above and below ground); iii) An underground space assessment tool which evaluates i) the natural ground conditions to inform potential hazards and potential resources (e.g. ground heat and water), and ii) underground infrastructure e.g. basements, tunnels, pilings.

By developing the use case solutions for integrated above-below ground city spatial planning the expert group were challenged to identify the need for the tool, how it would be used, who might develop it and the business case that supports its development. The outcomes from the use case development inform further activities on this topic including proposed work on a brownfield cost calculator tool and a proposal for cross-organisational prototyping of an integrated city mapping system. Outcomes from the workshop are also informing Think Deep UK a newly formed committee for the management of urban underground space.

This report documents outcomes from a workshop run in September 2015 at the Urban Innovation Centre on the topic of City Spatial Planning and Modelling. The workshop was organised by NERC knowledge exchange fellow, Stephanie Bricker in partnership with the Future Cities Catapult. The fellowship aims to improve the way that environmental data is used in cities to tackle urban challenges. The Future Cities Catapult accelerates urban ideas to market, to grow the economy and make cities better and was established by Innovate UK. All images and materials are copyright NERC.

Session 1: Issues and ideas

An overview of the city challenges around spatial planning and subsurface management were presented and then discussed amongst the expert group. The issues and potential opportunities were captured during the breakout session and focussed on four challenges areas, commercial issues, technology development, people and policy and scientific knowledge.

	Issues	Ideas
Commercial	▪ Ownership of data by private companies. ▪ Understanding commercial value of data. ▪ Levels of access to data requires thought e.g. for interpretation; analytical tools. ▪ Investment ahead of need is limited by utility company five year plans. ▪ Short-term view of infrastructure providers; only go where there is demand; developers unwilling to pay for front loaded infrastructure.	▪ Data ownership and government directive for its release. ▪ Legislation UK-wide to allow public sector to front load infrastructure to unlock brownfield for development. Allow public sector to benefit from profit of sale to unlock more land. ▪ Utility company infrastructure development plans need to be flexible enough to match city development needs. ▪ Encourage release of private data into public domain.
Technology	▪ Geotechnical variation: how to acquire data and model. ▪ Information is lost in translation - need to account for different audiences and levels of technology capability. ▪ Software compatibility remains an issue across platforms. ▪ Multiple outlets for same data. ▪ Accuracy of data and need for updating datasets. ▪ Storing raw versus interpreted data.	▪ Resource management e.g. use waste heat from assets like the London Underground. ▪ Data standards (formats, use, sharing, updating) and data sharing networks. ▪ Benchmarking against others. ▪ More value in using source data for different applications. ▪ Connection of land registry/OS to subsurface data. ▪ Create a 'Hub and spoke' city model where each domain-expert retains ownership of their models (spokes) but it's accessed via a central shared hub.
People and Policy	▪ Silo mentality of data generators: o My data – not sharing o My profit – want to sell ▪ Silo's based on domain-expertise. Need people with the big picture. ▪ Perceptions on urban	▪ Tailoring information for specific decisions. ▪ More spatial modelling needed. ▪ Stronger leadership needed. ▪ Create place-making policy ▪ Should policy be national or city-

	underground space limit joined up city plans for whole city space. ▪ Value creation ▪ Different challenges are faced in different places. ▪ Losing ownership of data/models when opening them up. ▪ Who will regulate new policy? Piecemeal responsibilities.	region specific? ▪ Should cities commission their own research, projects, policy-reform? ▪ Sharing of good practice.
Science and knowledge	▪ Advancing data storage and data manipulation. ▪ Academic 'ta-da' moments that don't get used because they haven't talked to people on the ground dealing with the problem. ▪ More concentration on other space than underground space – investment is needed. ▪ No recognised standards for baseline monitoring.	▪ Joint working bringing real world professionals together with academics. ▪ Create awareness of the potential use of urban underground space. ▪ Make sure solutions are achievable in reality but be innovative.

Session 2: Tools for city spatial planning

A timeline of data protocols, spatial planning tools, modelling technologies and policy guidance was presented highlighting the range of tools that are available to help provide solutions to improve city planning. Attendees provided a 'future look' of emerging technology and anticipated policy change that is likely to shape city development in future.

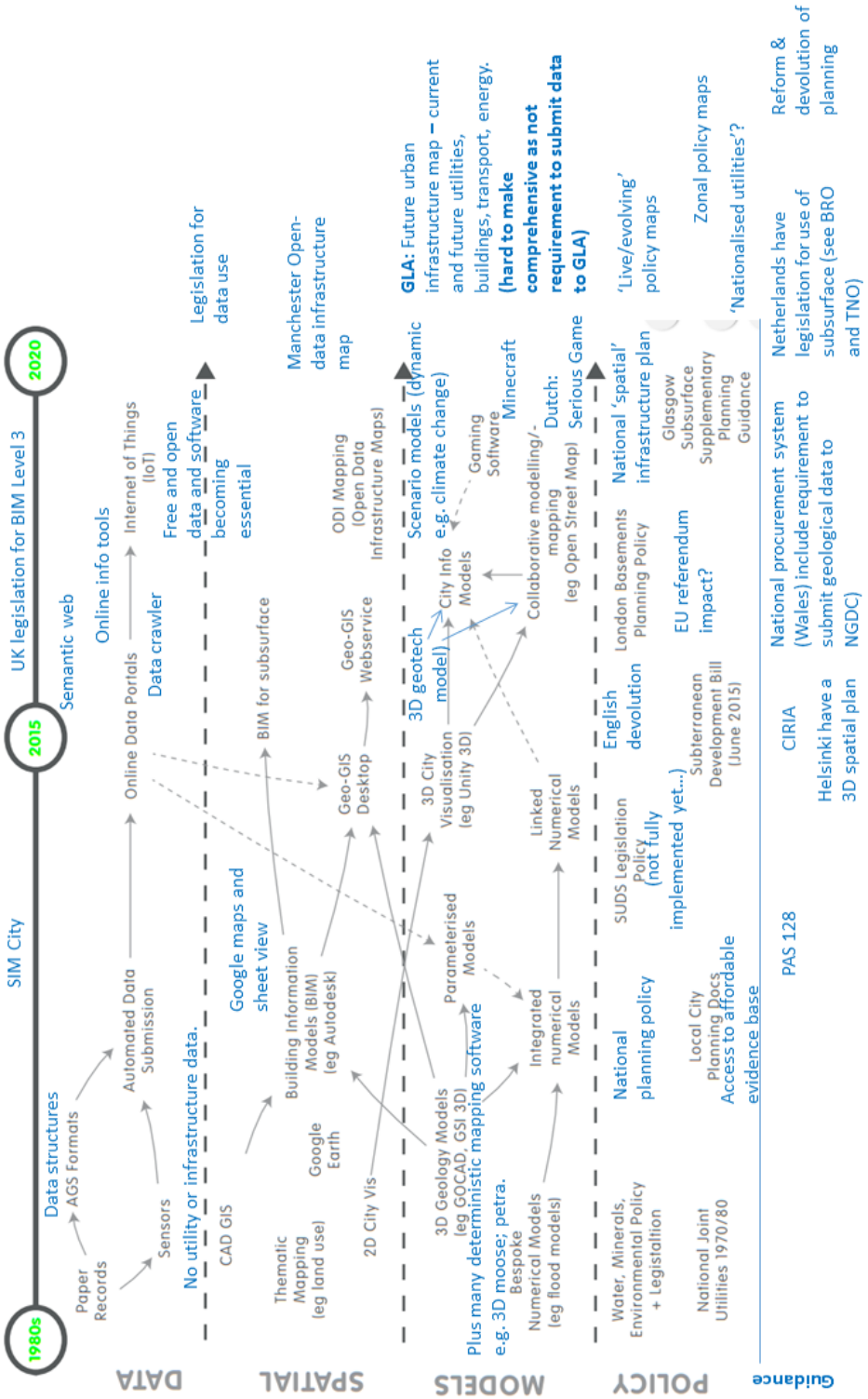


Figure 1: timeline of data protocols, spatial planning tools, modelling technologies and policy guidance. Text in blue was added by the expert group during the workshop.

Session 3: Developing use cases

Having gained an understanding of the main challenges for city spatial planning and having reviewed the tools available to help tackle these challenges, experts at the workshop co-developed ideas for tools and solutions focussed on specific use cases. The following example was presented to the group to aid discussion on potential solutions and what needs to be considered when developing a use case.

Example

City info model: 3D city BIM-style model that provides integrated data and info for your site and surrounding area.

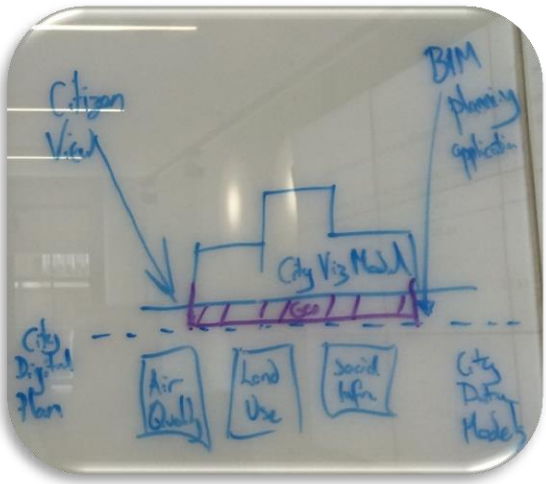
Features of the model:

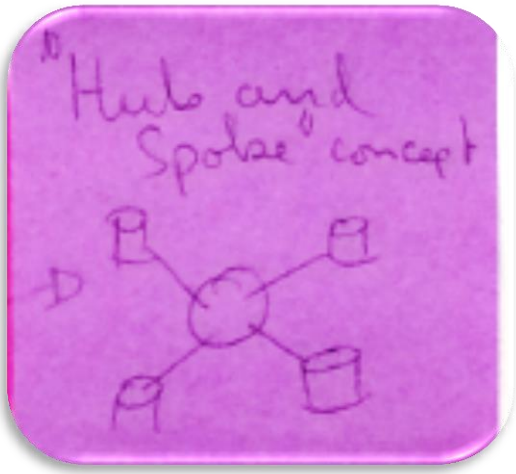
- Identifies planning constraints
- Identifies utility services, capacity in the system and opportunities for linked services
- Uses environmental info to inform the design of the building
- Provides an interactive 3D view of the development and relationships with existing buildings and e.g. lines of sight.

Things to consider:

- Who will use this tool?
- What will it be used for?
- Why it is needed?
- What technology/innovation is needed?
- Who would develop it?
- What is the business model?

i) City Information Model:





What is it?

- A platform that provides decision support systems by bringing together different city datasets using interoperable software.
- Capability for live data feed into the model
- Open data and restricted access options e.g. secure delivery outputs.
- A centre datastore for data collected during new development.
- Includes metadata – information on accuracy and usability of data.

Why is it needed?

- Allows safe planning and decision-making with a robust evidence base.
- Current planning approaches don't take full advantage of existing datasets or emerging digital technologies.
- Collective access to standard/approved data.
- Facilitates more rapid prototyping of new tools and data services as all the data is in one place.

Who will use it and how?

- All city practitioners including private sector (utilities) and public.
- Decision making based on multiple spatial datasets and timeseries 'live' data.
- Web interface and data portal which brings info together on demand.
- Mobile functionality through apps linked to central model.

How could it be developed?

- Collaborative partnership between government agencies and city organisations with a remit for city planning, regulation and service provision.

ii) Complete City Mapping Platform:

What is it?

- An integrated city mapping system for the collection, archiving, release and visualisation of data across the whole 3D form of the city (full height and depth above and below ground).
- Brings together existing data standards for e.g. AGS, BIM, CityGML).
- Cross-organisational responsibilities are addressed e.g. OS surface mapping, utility data information, BGS subsurface geological mapping.
- A digital platform which allows all mapping data to be integrated.
- Development of apps and tools that are developed using the digital platform.

Why is it needed?

- City mapping is still largely 2D, the 3D physical form needs to be considered when planning future development in the city e.g. roof and wall gardens; management of urban underground space.
- There is no shared standard for mapping underground infrastructure and no one organisation with a mandate to take ownership of this issue.
- Coordination of utility information above-below ground to prevent conflicting use of space, unnecessary road works, cable strikes and damage to underground infrastructure, maximise multiple use of space e.g. buildings & green infrastructure.
- 33% cut in project costs sought by government for construction and whole-life cost.

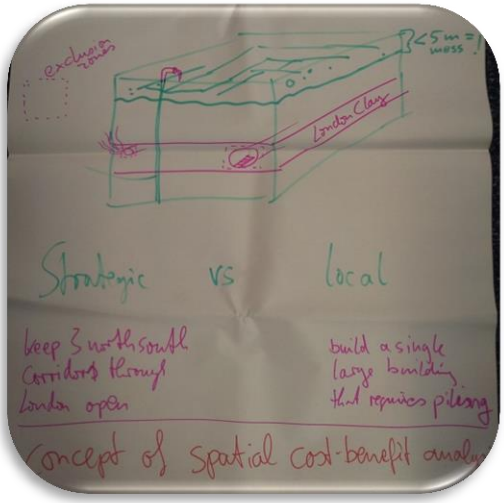
Who will use it?

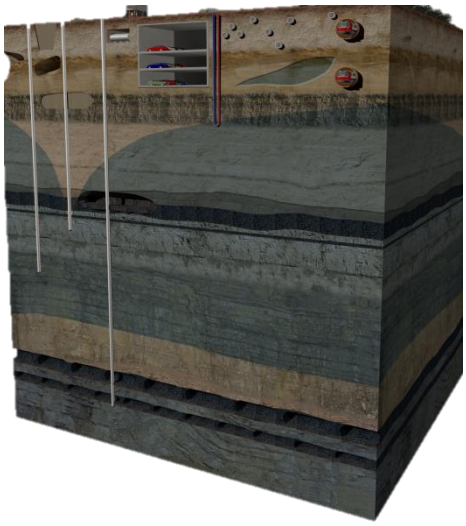
- City local authorities; utility companies; developers to assess where city infrastructure exists (current and planned) so new development can be maximised without compromising existing assets and functions.

How could it be developed?

- Partnership between the Ordnance Survey, 3D city modellers, British Geological Survey, British Standards Institute, Utility Companies, Future Cities Catapult, Land registry.

iii) Underground space assessment and planning tool:





What is it?

- A 3D assessment of the urban underground space which includes i) the natural ground conditions to inform potential hazards and potential resources (e.g. ground heat and water), and ii) underground infrastructure e.g. basements, tunnels, pilings.
- A spatial assessment of ground with favourable conditions for different activities can be identified.
- Land that is likely to be more cost-effective for development is highlighted.
- What if scenarios (e.g. planned pipelines) can be run to highlight hazards and opportunities in a low-risk pre-development stage.

Why is it needed?

- To de-risk investment and unlock potential resources.
- Physical ground constraints**:** Late stage awareness of ground properties and physical constraints to planned development is costly – Ground risks are one of main causes of project delay (50%), and of Insurance claims on completed projects.
- Alignment of Crossrail was influenced by the need to avoid over 200 existing obstructions and Crossrail2 is to be re-routed via Balham because of geological concerns.
- In 2013/14, three water companies in the UK spent an additional £80 million in responding to the impacts of groundwater infiltration into the water pipe network.
- 76% of London's total heat demand could be met by secondary sources (heat air; water treatment works and ground heat).
- Increased use of open-loop ground source heat systems is causing localised warming of groundwater.
- Applications for 450 basements in Kensington & Chelsea in 2013.

Who will use it?

- Developers, city planners and government agencies to look at the subsurface constraints and geological opportunity to inform site-specific planning and development and strategic city plans (e.g. energy and water resource supply and infrastructure).

How could it be developed?

- Collaboration between city authorities, British Geological Survey and owners of underground assets.

Existing projects and funded research

Data and technology

- BIM for the Subsurface | Keynetix and BGS
- NERC KE – Environmental Data for Future Cities | BGS
- TOMBOLO | Future Cities Catapult and Space Syntax
- Engineering geotechnics property model |Swanton Consulting
- City modelling |Centre for Advanced Spatial Analysis (CASA)

Planning

- Foresight Future of Cities| GO Science
- COST SUB-URBAN | BGS
- NERC KE – Subsurface Planning for Glasgow | BGS and Glasgow City Council
- THINK DEEP UK| ITACUS/BTS
- Manchester Integrated Infrastructure Map and Use Case tools |Future Cities Catapult and AGMA
- Underground Urbanism | Urben

Research

- Solving Urban Challenges with Data |Innovate UK/ESRC/NERC
- Environmental risks to infrastructure (inc. info on funded projects) |NERC
- Environmental Science to Service Partnership (Common environmental data portal and API)| NERC; Met Office; OS; Environment Agency.
- Mapping the Underworld / Assessing the Underworld ESPRC grants |Birmingham University

Follow-on activities and collaboration

Topic	What?	Who?
City mapping platform	The use case developed on a 3D approach to city mapping standards and models is being taken forward by the Future Cities Catapult, NERC (BGS) and the Ordnance Survey (OS). A project outline has been prepared and funding routes for a prototype are being pursued.	Future Cities Catapult; NERC(BGS); Ordnance Survey
Brownfield cost calculator tool	A follow up meeting with Manchester local authority and the Homes and Communities Agency highlighted the potential for a brownfield cost calculator tool. The tool would bring together various environmental datasets, planning information and economic information to highlight where redevelopment of brownfield land is most cost-effective. A proposal to prototype the tool for Manchester has been submitted. A linked KE fellowship proposal on Brownfield development is being developed.	Future Cities Catapult; NERC; BGS; Association of Greater Manchester Authorities (AGMA); Homes and Communities Agency.
Glasgow spatial planning	Glasgow City Council are introducing supplementary planning for the subsurface in conjunction with BGS through a NERC KE fellowship. Following the workshop the OS are working with them to help create a demonstration of an integrated above-below ground city BIM system.	Glasgow City Council; Ordnance Survey; NERC (BGS).
Data exchange and BIM demonstrator	Through the BGS national capability programme and a linked NERC secondment with the Environment Agency new protocols for data exchange have been agreed and a cross-organisation demonstration of the use of BIM is underway.	NERC (BGS); Environment Agency
Urban Underground Space	A new committee has been formed called Think Deep UK which aims to reform the management of urban underground space through better planning and policy. Outcomes from the workshop are informing the aims of the group and planned activities.	Dr Sauer & Partners; Urben; CH2M; ITACUS; BTS; NERC (BGS); Weston Williamson + Partners

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Hidden Depths: City Spatial Planning and Modelling

Friday 25 September 2015 | 9.30am – 4.00pm | The Workspace

Agenda

Session One: The Challenge

Welcome and introduction
Stephanie Bricker, *Team Leader Urban Geoscience, British Geological Survey*

Exploiting the City Subsurface
Helen Reeves, *Director for Engineering Geology, British Geological Survey*

Cities Lab
Adam Rae, *Senior Data Scientist, Future Cities Catapult*

Breakout: Issues and ideas

Session Two: Demonstration

Using Underground Space in Cities –
Elizabeth Reynolds, *Director, Urben*

BIM for the Subsurface
Gary Morin, *Technical Director, Keynetix*

Manchester Infrastructure Growth Tool
Stefan Webb, *City Project Developer, Future Cities Catapult*

Breakout: Tools timeline

Session Three: Innovation

Industry Insights
Martin Knights, *Managing Director, CH2M*

Subsurface Planning for Glasgow
Gillian Dick, *Principal Place Strategy & Environmental Infrastructure, Glasgow City Council*

Innovation at Ordnance Survey
Rollo Home, *Geospatial Product Development Manager, Ordnance Survey*

Breakout: Use-case creation

Session Four: Horizon scanning and future steps

3.50pm Summary and close

Attendees

First name	Last Name	Organisation	Role
Simon	**Mabey**	**Arup**	City modelling
Hannah	**Field**	**ARUP**	Project manager
Bill	**Clee**	**Asset Mapping**	
David	**Hodcraft**	**Association of Greater Manchester Authorities**	GMCA/AGMA Planning and Housing Team
Anne	**Kemp**	**Atkins Global**	Director
Roger	**Bridge**	**Balfour Beatty**	Tunnelling Manager
Conor	**Moloney**	**BDP**	Urban Designer & Planner
Guy	**Thomas**	**Blue Yonder**	Modeller
Helen	**Reeves**	**British Geological Survey**	Science Director Engineering Geology
Stephanie	**Bricker**	**British Geological Survey**	Team leader Urban Geoscience
Helen	**Bonsor**	**British Geological Survey**	NERC KE Fellow
Holger	**Kessler**	**British Geological Survey**	Team leader Modelling Systems
Jenny	**Forster**	**British Geological Survey**	Business Development
Lyzette	**Zeno Cortes**	**CASA, UCL**	City modelling and visualisation
Martin	**Knights**	**CH2M**	Managing Director: Tunnelling and Earth Engineering Practice
Janet	**Laban**	**City of London Authority**	Senior planning policy
Tim	**Hughes**	**CyberCity 3D**	Director
Karen	**Alford**	**Environment Agency**	BIM/GSL Programme Executive
Jane	**Birks**	**Environment Agency**	
Stefan	**Webb**	**Future Cities Catapult**	City Project Developer
Rudi	**Ball**	**Future Cities Catapult**	Senior data scientist
Adam	**Rae**	**Future Cities Catapult**	Senior data scientist
Gillian	**Dick**	**Glasgow City Council**	Principal Place Strategy & Environmental Infrastructure
Andrew	**McMunnigall**	**Greater London Authority**	Environment Programme Officer
Cllr John	**Bevan**	**Haringey Council**	Councillor
Antonia	**Cornaro**	**ITACUS**	Business Development Manager at Amberg Engineering & ITACUS Vice Chair
Han	**Admiral**	**ITACUS**	ITACUS Chair, Underground Space Thought Leader
Gary	**Morin**	**Keynetix**	Technical Director
Rollo	**Home**	**Ordnance Survey**	Senior Product Manager

Darren	**Page**	**OTB Engineering**	
Joe	**Kilroy**	**Policy Officer**	Royal Town Planning Institute
Alan	**Muse**	**Royal Institute for Chartered Surveyors**	Global Director of Built Environment Professional Groups
Hugh	**Unsworth**	**Swanton Consulting**	Associate Director Geotechnics
Mike	**Jones**	**Thames Water**	Water Resources & Process Modelling Manager at Thames Water
Nader	**Saffari**	**Transport for London**	Profession Head - Geotechnical Engineering
Keith	**Bower**	**Transport for London**	
Loretta	**von der Tann**	**UCL - Centre for Urban Sustainability and Resilience**	PhD Research Engineer
Carolyn	**Williams**	**Urban Vision**	
Elizabeth	**Reynolds**	**URBEN**	Subsurface Urban Development
Andy	**O Keefe**	**Virtalis**	Business Development Manager