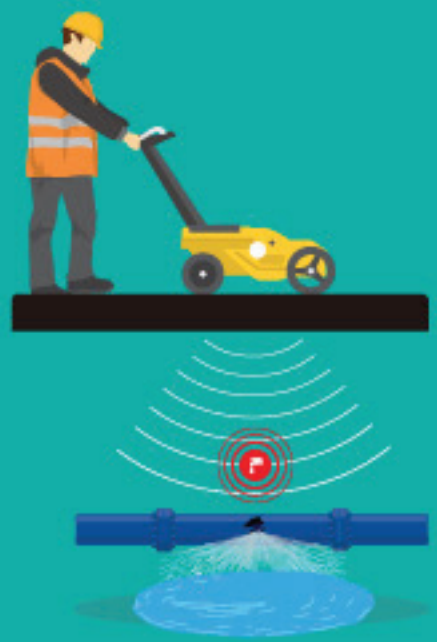
KPMG

Smart infrastructure: mapping underground utilities

Beneath our streets lie complex networks of cables and pipes – but often, the owners of these systems have little idea of their precise nature or location. Emerging digital technologies could enable us to build real-time, 3D maps of our buried utilities – reducing inefficiencies, costs and risks.



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The Smart Infrastructure series

Richard Threlfall

Partner

UK Head of Infrastructure, Building and Construction

Global Head of Public Transport

Infrastructure is all around us and ever-present in our lives: think of schools, roads, hospitals, power stations, telecommunications networks and sports facilities, to name but a few. Picture these in your mind and they are all quite, shall we say, solid. Made of bricks and concrete and steel and glass. Infrastructure is robust and long-lasting and inflexible. Until now.

In recent years, sectors such as communications and the media have been transformed by digital technologies; now infrastructure is in the foothills of its own technological revolution. And with that revolution comes a transformation in how infrastructure serves us, becoming more agile and responsive and clever.

By gathering, analysing and sharing new forms of data, we can improve and adapt decision-making in real time. By embracing the application of new technologies – such as driverless cars, smart electricity grids and adaptable buildings – we can drive up efficiency and realise new opportunities. And by building new data management systems and more flexible assets, we can improve collaboration and responsiveness – providing benefits for customers, managers and public agencies alike.

To help envision and promote that future, KPMG have conducted a series of thought leadership workshops – considering how we could use new technologies in infrastructure development, maintenance and operation to improve our lives, reduce costs, and create economic growth.

We imposed only a handful of rules on these workshops. All of our ideas had to be built around existing and emerging technologies; we've set our scenarios just a few years in the future. They had to have clear benefits for investors and managers as well as customers and public policy goals. And they had to be realistic and deliverable, addressing the potential concerns and challenges around matters such as privacy, security and governance.

Within those constraints, we've tried to step outside conventional thinking and test out new ideas. We want to stretch ourselves, applying new technologies and techniques to solve old problems. We want to think about how the world is changing, and how to stay ahead of that change. And then we want to bring that thinking back into today's world – mapping out the practical steps towards building a truly smart infrastructure.

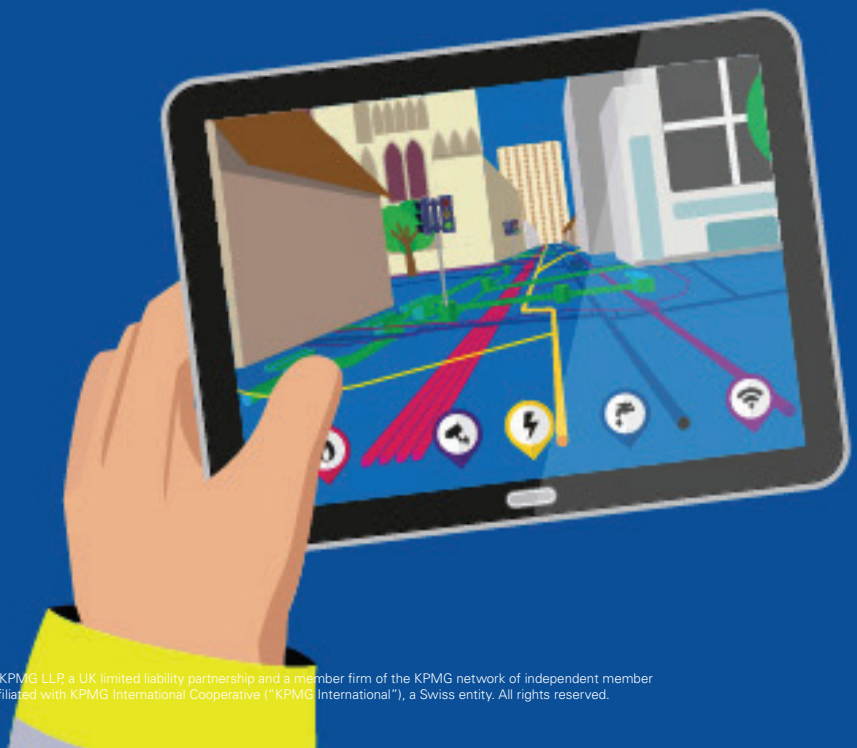
Mapping underground utilities

Like an old house, our urban infrastructure is shot through with hidden, unmapped conduits, pipework and cabling. But, given the right policies and collaborative working, today's technologies could enable us to create a real-time, 3D picture of our buried utilities – producing benefits for providers, customers and the general public alike.

As anyone who's ever bought an old house knows, a building's walls and floors can hide some nasty secrets. Remove plasterwork to replace the wiring, and you may reveal asbestos; take out a wall, and you risk uncovering an ancient gas conduit; drill to fit a picture hook, and you might just punch through a water pipe. Generations of workmen have come and gone, each of them adding or moving services; so the only way to find out what's behind paper, plaster and floorboards is to remove them and have a look.

The same is true, on a vast scale, of our city streets. Since Victorian times, utility firms and infrastructure providers have been burying pipes and cables beneath our roads – creating intricate, complex networks to distribute services and collect waste water. And over the centuries, almost all these organisations have folded or been sold, merged, nationalised, privatised or restructured, leaving asset records that are often incomplete and outdated.

Consequently, few utility and infrastructure organisations have an accurate, detailed picture of their distribution networks: to locate a particular conduit or junction, they must pull together whatever records they can find, carry out preliminary explorations using magnetic or electronic sensors, then cross their fingers and start digging. And with no universal system for sharing data between all the different utilities firms, they're just as likely to stumble across another provider's network as to locate their own.



The costs of inaction

The result is huge inefficiency, disruption and risk. Every works project demands trawls through the archive, new mapping exercises, exploratory digs, and the ever-present risk of hitting someone else's network – creating additional costs and delays as they're moved or repaired. And with few systems to coordinate utility providers' works within a geographical area, locations can be repeatedly excavated by a procession of different organisations. With providers digging some four million holes per year across the UK[1], the costs and economic damage caused by street asset works have been estimated at £5.5bn per year[2].

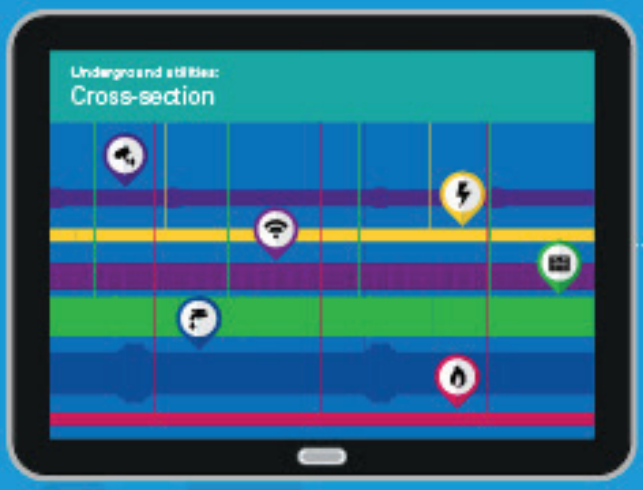
The system is made still more inefficient by its reactive nature. With such patchy records of their underground assets, utility providers cannot predict when a conduit is likely to fail. And even when they do think it worth carrying out checks or preventive maintenance on part of their network, they're often deterred by the protracted and challenging process for getting permission for non-emergency roadworks. The result is that most only respond once a pipe has burst or a cable snapped – creating additional risk, damage and disruption in the form of a flood, power cut or gas leak.

Mapping a way forward

Yet emerging digital technologies promise to do away with much of this extra work, wasted money and unnecessary disruption. Within a few years, infrastructure providers could create and share a detailed map of the utilities lying under the vast majority of our streets; and in time, we could shift towards a preventive maintenance model – using management information and live data feeds to head off failures before they occur.

Just a few years ago, we couldn't have mapped the complex, three-dimensional groundscapes lying beneath our roads and pavements; but the development of advanced sensors, rapid progress in robotics, and the crash in the price of data storage have opened up new possibilities.

Many technology businesses are developing detection systems that can locate and identify buried utilities to a high level of accuracy, and data hubs that would allow each utility owner to update and add details of their own assets[3]. Underground electricity cabling is relatively easily identified using sensors that pick up electrical fields. Meanwhile, engineering and AI firms are producing robots capable of exploring and inspecting water and gas pipes[4]; increasingly, these are able to use motion sensors, cameras and ground-penetrating communications systems to generate detailed plans of underground conduits.

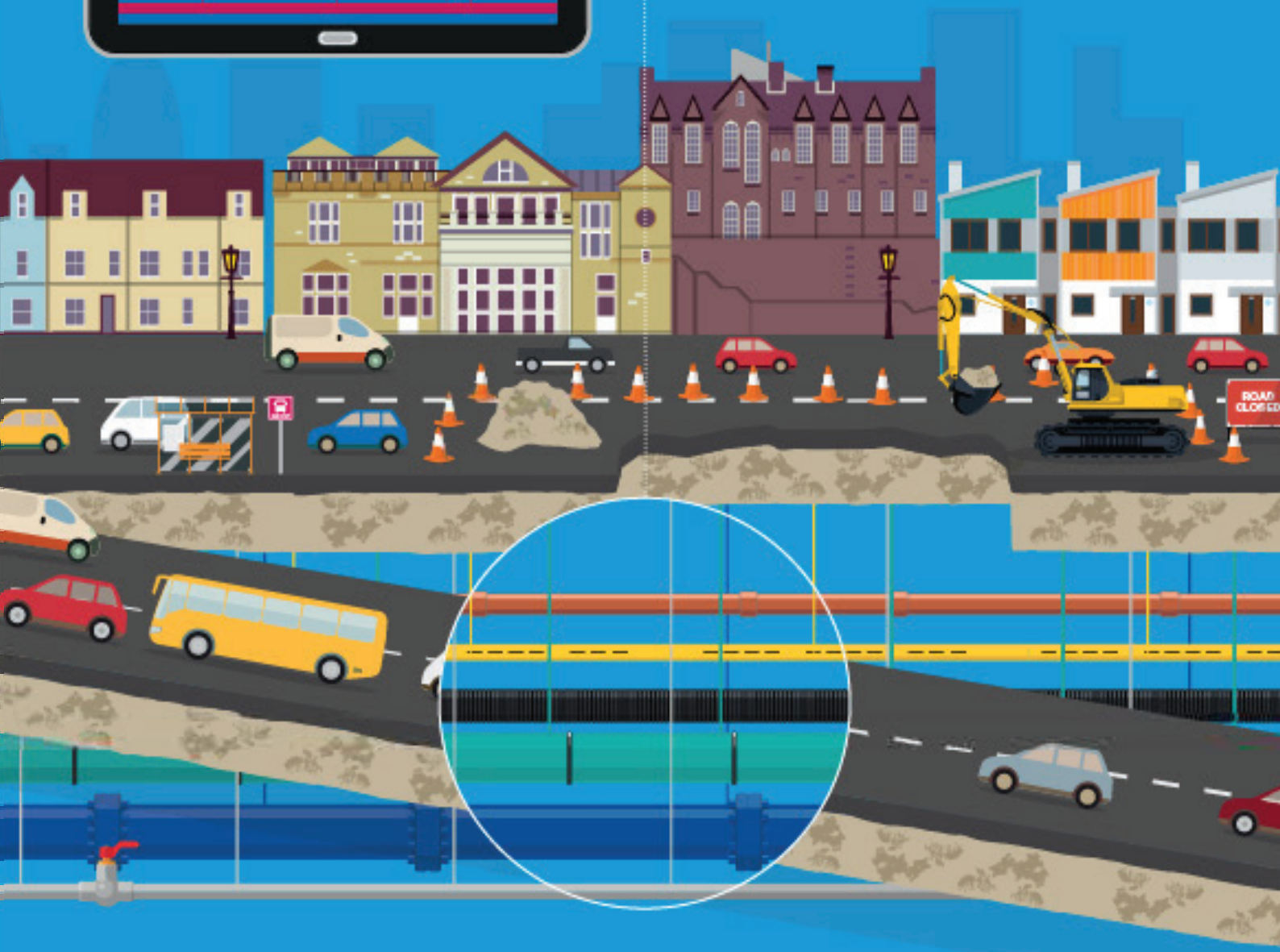


[1] Beck, R., Fu, G., Cohn, A., Bennett, B. and Stell, J. (2007) A framework for utility data integration in the UK, in Coors, M., Rumor, M., Fendel, E. and Zlatanova, S. (eds) Urban Data Management Society Symposium, (Stuttgart, Germany, October 2007).

[2] Metje, N, Ahmad, B and Crossland, S. (2015) 'Causes, impacts and costs of strikes on buried utility assets', Institution of Civil Engineers, Municipal Engineer, 168, 3: 165-174.

[3] http://smarterlondon.co.uk/news/competition-winners-pitch-tech-innovations-to-map-londons-utilities-underground/

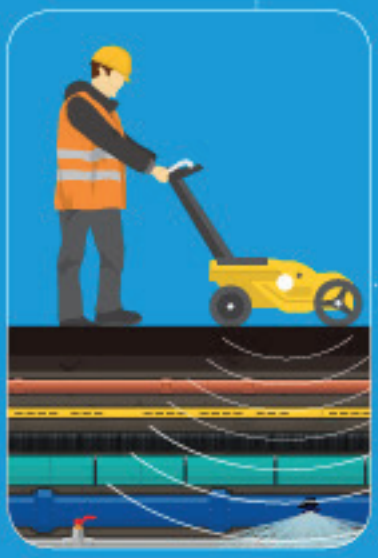
[4] http://www.imeche.org/news/news-article/robot-will-check-underground-pipes



Delivering a solution

So we'll soon have the technology to generate, hold and update a comprehensive map of the UK's underground utilities. The costs would, of course, be substantial. But Google has found it cost-effective to drive, push, carry, cycle and sledge video cameras down most of the roads throughout the developed world[5], creating the Google Streetview system; and the potential financial benefits of mapping the subterranean systems beneath these thoroughfares are enormous. Bringing different providers' data together in a shared system, we could build a shared mapping tool that allows participants to view the entire lattice of interweaving networks.

[5] https://www.google.co.uk/streetview/understand/



The biggest challenges – as so often – would lie not in the practicalities of getting the job done, but in getting stakeholders on board: in creating a framework that fostered the necessary collaboration, producing advantages for all the key bodies involved in providing, maintaining and regulating our utilities. The benefits are obvious – reductions in works costs and accidental damage for providers, and in disruption to roads and services for consumers. But many utilities providers would be reluctant to share data and to integrate their systems with a central database: vested interests and issues around competition, security and confidentiality present hurdles demanding a strong push from central coordinators.

To realise the full benefits of these technologies, we'd also need to reform the process for approving non-emergency roadworks – streamlining the system, and integrating it with the shared-access mapping tool to coordinate planned excavations. Much has already been done here to drive change, notably through the Highways Authority and Utilities Committee (HAU)[6] and StreetWorks UK (formerly NJUG[7]), but further reforms would be required to remove bureaucratic barriers and support truly collaborative working between utility providers.

If these barriers could be overcome, though, a shared 3D map – hosted on a secure online platform, and perhaps viewed using virtual reality technologies – would provide the basis for a wholesale move to preventive maintenance. Planned excavations could be displayed on the system, enabling other providers with assets in the location to request a simultaneous inspection of their own conduits, to send their own staff to the dig – avoiding the delays that occur when one provider needs another's assistance to access their networks – or to take the opportunity to upgrade and modernise their local network. Giving service providers details of others' underground networks would reduce the incidence of accidental damage during exploratory digging, minimising repair costs, service outages and road closures. And all the information on conduits' routes and networks' condition gathered during excavations could be fed into the system, steadily improving its richness and accuracy.

[6] http://www. hauc-uk.org.uk
[7] http://njug.org.uk

Longer term goals

Over the longer term, emerging smart infrastructure technologies are likely to further strengthen predictive maintenance. Newly-installed conduits could contain sensors able to detect wear, strain and emerging fractures or leaks, sending data to utility owners via links to surface transponders using 5G or broadband networks. And information on predicted asset lifespans could be fed into the mapping system, providing alerts as systems approach their scheduled maintenance periods.

Giving other relevant bodies access to the online platform could further streamline the process. Local authorities and transport managers, for example, would have much better information on the likely duration and extent of underground works, improving their traffic management and public information campaigns. Revealing which services might need to be moved to provide access to pipes and cabling, the system would permit planners to give public services, businesses and domestic consumers more notice of possible outages. And with service providers updating the platform in real time, emergency services would be informed much more quickly as roadworks are planned, initiated and wrapped up.

Over hundreds of years, we've built a massive and intricate world of interwoven underground networks, comprising up to 300 separate systems ; yet there are huge gaps in our data on what we've created. Now, the power of digital technologies to gather, store and share information presents a way for us to rediscover that knowledge – promising both huge savings in utility firms' maintenance and repair budgets, and a big reduction in the economic harm caused by roadworks, accidental damage and network failures. Indeed, the biggest challenges to this concept are not technological, but organisational – lying in the policy framework reforms that will be required to get stakeholders working together to their mutual benefit.

Previous generations have bequeathed us a rambling, tumbledown mansion shot through with ageing pipework, hidden conduits and long-buried wiring. Thanks to the potential of smart infrastructure, we could soon be able to don our X-ray specs and consult a network diagram before getting stuck in with the DIY.

[8] Mayor of London (2013) Smart London Plan: Using the creative power of new technologies to serve London and improve Londoners' lives, Smart London Board: London. And GLA (2014) GLA Networked Utilities: Summary of Stakeholder Workshop, Arup: London.

Contact us

Matthew King

Associate Director Infrastructure Advisory

KPMG LLP

T: +44 20 7311 1444

T: +44 7464 980 648

E: matthew.king@kpmg.co.uk

Matt King is an associate director in the KPMG Asset Management Advisory business. He has a background in complex engineering procurement and development within the defence and transport sectors. He was recently the project manager of the Infrastructure National Needs Assessment working with the Institution of Civil Engineers and many other stakeholders to set out a vision for the nation's infrastructure needs to 2050. Matt is currently programme director for a circa £4bn multi-year asset management business plan for a major regulated transport infrastructure owner.

Salar Shemirani

Manager in Infrastructure Advisory

KPMG LLP

T: +44 20 7311 6108

T: +44 7795 426 667

E: salar.shemirani@kpmg.co.uk

Salar Shemirani is a manger in KPMG Infrastructure Advisory business with variety of advisory skills in asset intensive organisation and in specific strategic business improvement, operational transformation, finance transformation, asset management, capital delivery and Fixed Asset Register integrity. In his current role at KPMG Salar is responsible for providing strategic asset management advisory as well as finance and operational transformation support to a diverse range of clients in rail, utilities and retail sectors with large asset portfolios and have led and supported his clients in achieving their financial and operational performance targets.

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