

A2

NEW DIMENSIONS FROM ARUP | NO.19



Innovation in action

Smart thinking for business
and the built environment

ARUP



Innovation in action

Innovation is at the heart of the prosperity of a business and a society; it's what drives the world forward. To paraphrase Albert Einstein, you can't do the same thing over and over again and expect a different result. You have to innovate if you want to improve.

This is why Arup has always followed the philosophy of our founder, Ove Arup, whose legacy of innovation we examine in this issue.

And it's why, as we discover, major infrastructure organisations are, in the words of HS2's head of innovation Iain Roche, striving to ensure that innovation is "baked in, not bolted on".

Innovation is easy to talk about, but harder to do, and innovation has to be doing things. That's why Arup has put a lot of thinking into how we can lead the way. We take a look at how foresight can enable innovation by helping organisations understand and anticipate change. We also highlight our venturing initiative that's bringing Arup employees' ideas for game-changing technologies to market.

Advances in technology alone won't solve the challenges facing the built environment; they must be applied skilfully and responsibly. We see how Arup clients from London to Lahore are using new camera technology to ensure public safety and security without intruding on people's privacy.

In uncertain times, as our interviewee – CBI Director-General Carolyn Fairbairn – says, innovation is one way for businesses to succeed. Innovation will remain a key focus for Arup; it is in our DNA, and we'll remain curious about new ways to foster it, such as the start-up accelerator model featured in this issue.

I hope you enjoy reading A². To find out more about any of the stories featured in this issue, email a2@arup.com.

Alan Belfield
Arup Group

- 03 News
- 06 Britain after Brexit
- 08 Nothing ventured, nothing gained
- 12 Meet the world changers
- 16 Picturing innovation
- 18 Focussing on safety
- 21 Making it happen
- 24 Anticipate and align
- 28 The next big thing
- 30 Ove the innovator

A² magazine is a publication produced by Arup for our clients and reflects our mission to shape a better world.

For more information on any of the topics featured in this magazine, please visit www.arup.com or email a2@arup.com.

Editor Emily Binning

Design Matt Cox **Cover** Chris Baker **Writer** Polon

Published by: Arup, 13 Fitzroy Street, London, W1T 4BQ

Printed by: Park Lane Press on FSC certified 100% recycled paper, using fully sustainable, vegetable oil-based inks, power from 100% renewable resources and waterless printing technology. Print production systems registered to ISO 14001, ISO 9001, EMAS standards and over 97% of waste is recycled.



Meet two of our new leaders

Isabel Dedring joined Arup in March 2016 to become our new global transport leader, while Ian Taylor is our new global aviation business leader.

Isabel's career has taken her from advising on energy in Kazakhstan to pioneering environmental and transport initiatives in London. Her role at Arup will include helping clients to deal with the challenge of paying for transport infrastructure at a time when funding from governments is limited.

Ian joined Arup in 1993 and has worked in the UK, Ireland, USA and Asia. Since 2009, he has led our aviation business in East Asia. The award-winning aviation and transport projects Ian has worked on include Hong Kong International Airport, Terminal 2 Dublin Airport and San Francisco's Transbay Terminal.



Stavros Niarchos Foundation Cultural Center opens

The Stavros Niarchos Foundation Cultural Center provides new facilities for the National Library of Greece and the Greek National Opera, as well as a new park. Engineered by Arup, the centre opened to the public in the summer of 2016.

Our project manager David McAllister describes the centre as “the biggest, most functionally diverse and technically intricate cultural building” he has ever worked on.

To minimise the heat island effect from the development and improve its microclimate, the design team included a green roof and seawater canal system. They used sophisticated 3D modelling techniques to design the main 1,400-capacity auditorium. And they ensured the library provides exactly the right environment in each of its spaces, which include an archive for rare manuscripts.

Partnership with the Ellen MacArthur Foundation

The Ellen MacArthur Foundation has named Arup as its knowledge partner for the built environment.

The partnership was announced at the Foundation's 2016 CE100 Annual Summit in London. It means the organisations will be working together to develop circular economy principles across cities, transport, energy and water.

The Foundation's founder, round-the-world sailor Ellen MacArthur, commented: “We are excited to forge this new partnership with Arup to help drive a major shift in mind-set and behaviour across the built environment.”



Gregory Hodkinson, Chair Arup Group and Ellen MacArthur



Arup’s UKMEA region chair Alan Belfield and global fire engineering leader Barbara Lane have been awarded Royal Academy of Engineering Fellowships.

Alan has been recognised for his contribution to mechanical engineering, particularly in analysis-led design. His business skills and expert technical knowledge have seen him called on to represent the UK on international trade missions. He is also a member of the UK Government’s Professional and Business Services Council.

Barbara has been acknowledged for her contribution to the fire engineering profession. She has developed methodologies that have become standard industry practice. She has informed the construction of iconic buildings such as The Shard in London. And she has helped create the largest fire engineering department in the world, at Edinburgh University.

Celebrating two new Fellows



© Hayes Davidson and Herzog & de Meuron

Tate Modern extension opens

The extension to the Tate Modern gallery in London – the 11-storey Switch House – officially opened in July 2016.

The project, for which Arup provided engineering services, has added 60% more space to the gallery. It includes a new café and restaurant, a free viewing platform, a new members’ room, public engagement and education spaces, offices and two new public squares.



First collaborative trials of connected and autonomous vehicles

The Arup-led consortium UK Autodrive has held the first collaborative trials of connected and autonomous vehicles between multiple major manufacturers – Jaguar Land Rover, Ford and Tata.

The trials showed how different cars could ‘talk’ to each other. For example, they could warn drivers about other connected cars ahead breaking heavily. They could also use information from traffic lights to advise drivers of the optimum speed to reach the lights on green – improving traffic flow and reducing emissions.

The trials, at HORIBA MIRA’s Midlands test track, are part of a series that will take place over the next two years.

The most advanced reusable building yet

A prototype building with fully re-useable components has demonstrated how circular economy thinking can be applied to the built environment. Showcased at last year’s London Design Festival, The Circular Building seeks to explore how the industry can work towards zero waste.

The prototype is designed and built with materials that can be removed with minimum damage, helping each component to retain its value. Everything from window frames to individual fixings is digitally tagged with a unique QR code containing information allowing them to be reused.

Arup developed the building with Frener & Reifer, BAM Construction and The Built Environment Trust. Together with our report, *The Circular Economy in the Built Environment*, the project seeks to accelerate the shift to a circular economy.





Innovating Urban Energy

An Arup paper made a vital contribution to a flagship report launched at the World Energy Congress in Istanbul, October 2016. Our standalone perspective paper *Innovating Urban Energy* provided both insight and creative input to World Energy Scenarios 2016 – The Grand Transition.

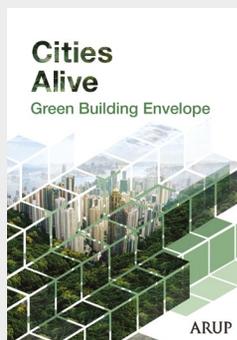
The paper and accompanying content at urbanenergy.arup.com explore five innovations that could help cities reduce the impact of urbanisation through energy efficiency.

New team will strengthen global resilience

A new £10m 5-year programme will see the Lloyd's Register Foundation and Arup join forces to make society's critical infrastructure more resilient to shocks and stresses.

The team will explore how resilience engineering can become a mainstream discipline. To this end it will work with businesses, engineers, researchers and others to develop standards and build networks of learning and best practice.

The Lloyd's Register Foundation selected Arup to run the programme because of our strong reputation for applying resilience engineering to real-world projects. "We believe this programme provides a unique opportunity to embed resilience into mainstream thinking and doing," commented Arup director Jo da Silva.



Living walls can tackle toxic air hot spots

Cities Alive: Green Building Envelope shows that the contribution of moss and vegetated walls, vertical farming and roof gardens, has been underestimated. Green envelopes, often dismissed as "architectural window dressing", can reduce localised air pollution by up to 20%, rapidly reducing toxic air at street level.

[Click to download the report from arup.com](#)



How can London adapt to climate change?

Managing London's Exposure to Climate Change, produced by Future of London in partnership with Arup, responds to the growing climate risk. It outlines recommendations to help London's public asset owners, as well as service providers and their partners, build ever-stronger business cases for adapting their assets to this mounting threat.

[Click to download the report from arup.com](#)



Healthy mobility infrastructure

New research aims to help decision-makers deliver better mobility infrastructure through a better understanding of how mobility affects health and wellbeing. The report is a collaboration between Arup, BRE, University College London and AREA (Perkins + Will).

[Click to download the report from arup.com](#)



Retrofitting homes to tackle climate change

Towards the Delivery of a National Residential Energy Efficiency Programme outlines how the UK can create the right conditions to halve the energy consumed in all homes within 25 years. The report addresses the vital issue of retrofitting the UK's 28 million homes, which are responsible for 30% of the country's greenhouse gas emissions.

[Click to download the report from arup.com](#)



Flexible and efficient power

A joint report from Arup and Siemens provides an insight into the world of decentralised energy. *Distributed Energy Systems: Flexible and Efficient Power for the New Energy Era* focuses on the economic viability and wider co-benefits of investing in decentralised energy systems.

[Click to download the report from arup.com](#)



To find out more and read our reports please visit publications.arup.com

BUSINESS AFTER BREXIT

As the UK prepares to leave the EU, CBI Director-General Carolyn Fairbairn talks to A² about how businesses can prosper – and what they can learn from Team GB's Olympic success

Is uncertainty the biggest Brexit risk for business?

Uncertainty is definitely a huge risk. There's uncertainty among businesses over the nature of the UK's trading relationship with Europe and the rest of the world. There's uncertainty over exchange rates – the recent volatility has affected many of our members. There's also uncertainty over the state of the UK economy and the economic and industrial strategy the country is going to pursue.

The swift appointment of a new Government helped restore a sense of calm after a couple of weeks of huge upheaval in the immediate aftermath of the referendum, but the Government will now need to start setting out its agenda – particularly around Brexit and industrial strategy – or this will start to fade quickly.

How can Government combat this uncertainty?

I think businesses are good at managing uncertainty, but that a stable trading environment would be very welcome. In areas of the domestic agenda where the government can already make progress, it must seize the initiative.

On the negotiations, we have called on government to be clear on the principles that will underpin the UK's new relationship with Europe, even though it can't be certain on exactly what Brexit will look like.

We also welcome the recent announcements on industrial strategy. But we'll continue to push for a long-term commitment to spending more on innovation – at a level that's much closer to the OECD average of 3% of GDP.

Universities have a vital role to play too. Institutions like Warwick, UCL, Exeter and others already have strong links with business and are creating science parks and innovation centres. Businesses are hungry for such partnerships and there's scope for them to work even more closely with what are, after all, some of the best universities in the world.

What can businesses do to prosper in such uncertain times?

I believe that a relentless focus on productivity, competitiveness and innovation will allow businesses to succeed. And many of them are already doing this.

At a recent manufacturing round-table in Birmingham, I heard how businesses were, in a way, already moving on from Brexit. They were thinking about ways to take advantage of the lower exchange rate. They were thinking how they could adapt to serve a global marketplace. And, above all, they were focussed on improving productivity.

Something that's going to become increasingly important in achieving this is the rate at which digital technology is adopted. The UK is ranked fourth in the world for digital availability – we are pioneering areas such as virtual reality – but we are only fourteenth in the world for take-up.

So what I think businesses need to ask themselves is what they can do to encourage faster digital adoption in pursuit of higher productivity – and what support they need to do it.



I believe that a relentless focus on productivity, competitiveness and innovation will allow businesses to succeed. And many of them are already doing this.

Is there too much focus on the negative potential of Brexit?

I think this is a time for confidence about the UK's economy, because I think there's a huge amount to be confident about. I recently visited BT's research centre at Adastral Park near Ipswich, and some of the innovations in the telecoms industry are extraordinary. The UK is leading the world, and I think it's time to shout about it.

I also think it's up to us as businesses to make these stories interesting for the media. If we tell these fantastic stories in human ways then they will hit home around the world.

For example, I heard the other day about how Capita is working with local authorities using big data to help identify children at risk. By using data sets from different sources, Capita has been able to identify several factors that can highlight when a child is likely to be abused. This process has produced a list of children at risk, something like 40% of who had never before made it on to an at-risk register.

What could business learn from Team GB's Olympic success?

As a nation, we need to feel pride in the pioneering work that businesses are doing – much as we feel proud of our successful Olympians. I think that we can learn a lot from Team GB's success in Rio.

Team GB's athletes had very clear goals, building on their success in London four years ago. And they set about achieving their goals, as individuals and a team, ruthlessly.

For the UK to become number one in the business world, I think it needs to harness some of that ruthless pursuit of improvement and apply it to productivity and innovation.

The CBI is the UK's most effective and most influential business organisation, speaking on behalf of 190,000 businesses of all sizes and from all sectors.

Five business principles for a successful Brexit

The CBI has set out five principles that its members believe should underpin the UK's negotiations with the EU:

1. Retaining the ease of UK-EU trade that businesses gain from the Single Market.
2. Balancing regulatory equivalence with the EU with flexibility and influence over the domestic environment.
3. Ensuring the UK's migration system allows companies to access the people and skills they need, while recognising public concerns.
4. Developing a clear strategy for international trade and economic agreements.
5. Protecting the economic and social benefits of EU-funded projects.

NOTHING VENTURED, NOTHING GAINED

Bringing game-changing built environment technologies to market can benefit everyone involved

Taking new products, software or businesses to market may not be what everyone expects from a professional services firm. So why is Arup involved in everything from inventing a revolutionary air-conditioning unit to pioneering a new geothermal business?

“Investing our own money means we can bring ideas to life that wouldn’t otherwise see the light of day,” explains our ventures manager Ralph Wilson. “And this benefits our clients.”

Ian Rogers, Arup’s global venturing leader, continues: “Venturing enables us to explore radical ways to bring our broad skills to bear on the huge challenges facing our sector – and to share in the value we create.

“Climate change, the rise of digital influences and data, and the emphasis on operational performance and wellbeing are going to affect our industry profoundly. At the same time, conventional commercial models are under pressure.

“Venturing is like a Petri dish. We can use it to experiment with going beyond what consultants have traditionally done and find new ways for our expertise to benefit clients.”

One product to emerge from this approach is a fan coil air-conditioning unit so slim developers can fit an extra floor into a 12-storey building without increasing the overall height. It’s a system that also has very low energy consumption, comparable with chilled beam units.

This ingenious idea, the brainchild of Arup engineer Roger Olsen who is profiled on page 15, would never have come to fruition without investment and nurturing.

Yet it has a very obvious commercial appeal.

Indeed, venturing helps to sharpen the firm’s commercial focus. “Venturing encourages our people to focus on the commercial aspects as well as the technical challenge,” says Ralph.

Commercial thinking is nothing new in Arup. Back in 2007, for example, our successful HaloIPT equity venture with the University of Auckland pioneered wireless charging for electric vehicles. In 2011, Qualcomm bought HaloIPT and Arup realised a substantial return from the equity sale.

Today, Arup’s approach to venturing embraces the philosophy of lean innovation. “Essentially, people bring ideas to the ventures team and, together with experts from across Arup, we help them commercialise those ideas.

“Exposing ideas early, both within Arup and externally to potential clients and partners enables us to see if they’re viable before investing lots of time and resources in them,” explains Ralph.

Yet ventures must also follow Arup’s long-established principles. So, Ian Rogers stresses, the sustainability of ventures is closely scrutinised. If an idea doesn’t have potential to really help shape a better world, it doesn’t see the light of day.

Together with technical and commercial demands, this makes venturing a challenging business. “We have to generate more income from royalties, licence fees and equity sales than we spend developing all of our ideas,” explains Ian.

“Most ideas fall away during the process. But experience tells us that our successful ventures will enable us to succeed – and that the ideas we harvest and develop can really help us to shape a better world.”

Photo: A trial for one of our ventures: an innovative living scaffolding wrap for construction sites

Arup ventures in development

HIDDEN LAYER

This equity venture aims to commercialise an Intelligent Demand Optimisation System (IDOS). IDOS is a demand-control technology with battery storage that enables a house to behave as a smart energy system. With IDOS, homeowners can use low-cost energy at any time, export surplus energy from solar panels to the grid and save money.

GEON

This equity venture aims to establish deep geothermal heat as a major part of the UK's low-carbon heating portfolio. It will use 2km-deep wells to heat residential and commercial developments, campuses, hospitals, and small industrial facilities in a way that is more resilient, lower risk, and with lower life-cycle costs than alternatives.

LIVING WALL LITE

Living Wall Lite is a new concept for living walls, in which plants are grown from seed in situ, rather than pre-grown in off-site greenhouses and installed in place on site. The result is a system that's lower cost, lower maintenance, and less carbon-intensive than alternatives.

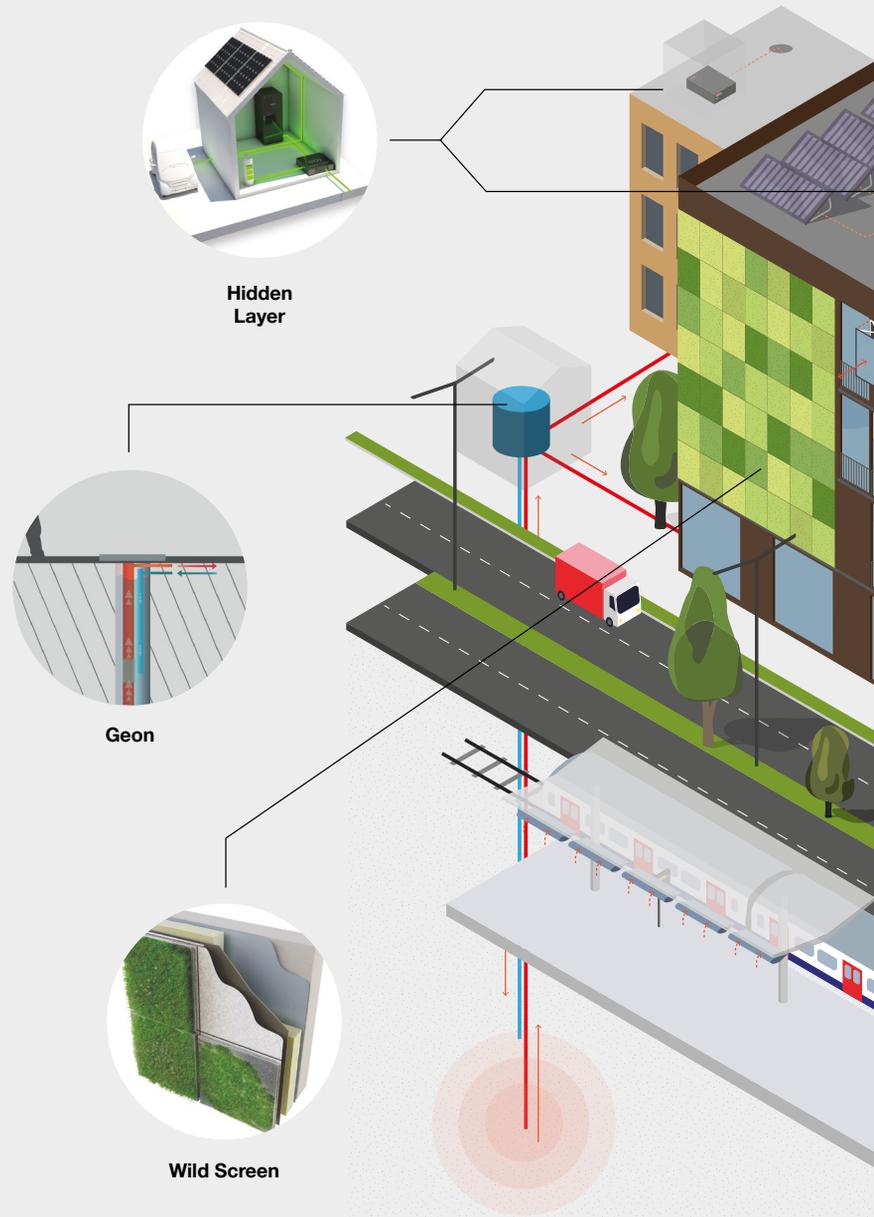
There is both a lightweight permanent façade version, and a temporary version for use on construction site scaffolding and hoarding. The latter is undergoing trial on two project sites in London, for Skanska and Grosvenor Estates.

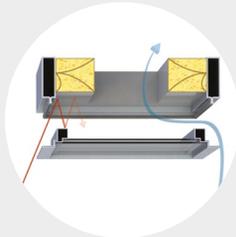
"Grosvenor is keen to try and push the boundaries on how we can improve the historic fabric of the estate by trying new technologies and products. St Marks provided the ideal opportunity for us to try the new green wall technology and the response from the community to this initiative has been very positive."

Mark Tredwell, Development Director, Grosvenor

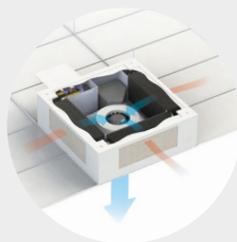
"Our office is directly opposite the living wall and it has been a welcome change to see green plants and flowers sprouting from the scaffolding rather than the usual plastic cover or worse still nothing but the scaffolding."

Sarah-Jane Kavanagh, Patronus Partners

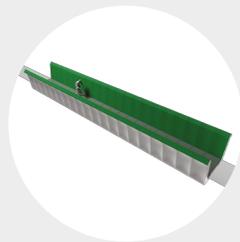




Sound Attenuating Façade Element



Hybrid Fan Coil Unit



arcoBridge

SOUND ATTENUATING FAÇADE ELEMENT

How can you let fresh air into residential and office buildings while keeping unwanted noise out? It's an ever-growing problem in our busy urban environments. The Sound Attenuating Façade Element's patented rib system is tuned to attenuate noise while providing a free opening for natural ventilation.

HYBRID FAN COIL UNIT

This new ceiling-based air-conditioning system offers the flexibility of a fan coil system with the low energy consumption of a chilled beam. It costs the same or less than conventional systems but needs around 300mm less ceiling height, creates a less cluttered ceiling void and is self-commissioning and self-access for maintenance.

ARCOBRIDGE

A lightweight glass fibre reinforced plastic (GFRP) modular footbridge system, arcoBridge is especially suited to difficult sites. It's 70% lighter than a conventional steel span, with lower lifetime costs, and can be wheeled around site by hand.

"I can see clear benefits of using arcoBridge where the ground is poor. Modularity is also good for quality and spare parts. And there would be benefits if using road-rail install rather than crane."

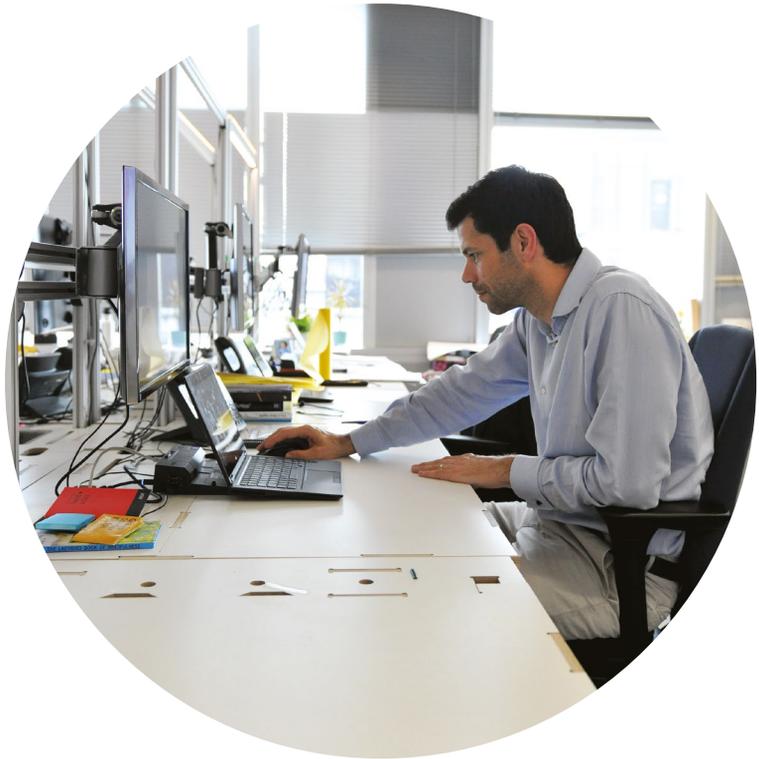
Stewart Lothian, Scotland lead structural engineer, Network Rail

Venturing is like a Petri dish. We can use it to experiment with going beyond what consultants have traditionally done and find new ways for our expertise to benefit clients.

Ian Rogers, Arup's global venturing leader

MEET THE WORLD CHANGERS

A² talks to the people behind the bright ideas



For Michael, it's all about the desk

Michael Trousdell is one of the originators of a project investigating how internet-of-things technology could revolutionise workspaces

“I often found myself sitting at my desk frustrated with how little control I had over my environment,” says mechanical engineer Michael Trousdell. “The lighting would be too dark for what I was doing or the temperature wouldn’t be comfortable for me. But things would have to get really bad before I got up to try and change them.”

Building occupant surveys show many office workers share Michael’s frustration, so he helped instigate a new research project aimed at making more productive, comfortable and customisable workspaces. All About the Desk is looking at how incorporating low-cost mobile technology and sensing, driven by open-source software, into a desk made using rapid manufacturing techniques could shake up the industry.

Using internal funding, a team of specialists from across Arup set about realising the vision for the desk by constructing a demonstrator.

“Bringing different ideas from all these disciplines together into a physical demonstrator has been a great learning experience for everyone involved,” says Michael. “Of course, getting this done on top of our day jobs has been quite a challenge. While client work has to take priority, we believe it’s important to set aside time for research like this because it could help shape the future of the industry.”

Six demonstrator desks are currently installed in Arup’s offices in London, with the All About the Desk research team gathering feedback from users.

A new kind of desk

1. The desks incorporate a safe and flexible extra-low-voltage DC power supply with a single cable carrying both power and data.
2. With each device securely connected to the intranet, it’s easy to collect data such as power consumption or temperature readings.
3. An open source controller will connect the desks to the building’s cooling system, giving users greater control over comfort conditions.
4. The desk’s lighting changes during the day to complement the users body clock, and it can be controlled through the user’s mobile device.
5. Rapid manufacturing enables the fully customised desks to be made locally – saving time and reducing environmental impact.
6. 3D printing enables bespoke components of the desk to be produced without significant costs or lead times.



Live data from the desks is reported on the project’s website at allaboutthedesk.arup.com

How Roland is helping bridge a gap in the market

A chance conversation over a cup of tea led to a revolutionary new footbridge system

One day, Roland Trim, the leader of our Advanced Technology and Research team in Bristol, joined structural engineer Ian Wise for a cup of tea. Neither of them could have foreseen that their discussion would lead to a groundbreaking innovation.

“Ian wanted to enter a bid for a project to build a footbridge in the middle of a forest, where the only access was by quad bike,” Roland explains. “The question was how to build it, given that the client didn’t want to do the obvious thing and fell a tree to use for the structure.”

Roland and Ian considered all the options for a modular bridge that could

be transported and erected in sections and came up with a new approach. “On the face of it, a composite like glass fibre reinforced plastic (GFRP) didn’t seem suitable, but we thought: ‘What would happen if, instead of gluing the modules together, you pushed them together in compression?’ We realised we were on to something.”

Although Roland and Ian didn’t win that bid, they retained the intellectual property for an idea that overturned conventional thinking on GFRP structures. Through Arup’s venturing initiative they secured £180,000 to build a prototype and patent the design, and arcoBridge was born.

A lightweight GFRP modular footbridge system, arcoBridge is especially suited to difficult sites with rail, road and river spans.

With the demonstrator proving the potential of the idea, Network Rail accepted arcoBridge for use in the UK. The first installation is nearing completion on a site near Oxford, and there are more projects in the pipeline.

“Manufacturing the bridge under licence will enable clients to competitively tender for state-of-the-art GFRP bridges,” Roland explains. “So perhaps the biggest benefit of arcoBridge is that it will open up the market in the UK for composite bridges.”



Capital costs are comparable with steel footbridges; operating costs over its 120-year design life are lower.

Over 70% lighter than a conventional steel span, arcoBridge is easier to install – even where access is limited or difficult.

The Hybrid Fan Coil Unit is a great and innovative British idea that deals with the shortcomings of almost all the existing cooling and heating technologies available.

George Hannah, Technical Director, Airedale International Air Conditioning Ltd

Roger's fresh approach

After 30 years designing air-conditioning systems, Roger Olsen knew there had to be a better way



Frustrated by the drawbacks of the air-conditioning options available, Arup engineer Roger Olsen came up with his own revolutionary concept: the Hybrid Fan Coil Unit.

Roger envisaged a unit with a redesigned, larger heat exchanger and a low energy fan that would use less energy and save space. "I kept the idea quiet for two or three years, thinking and sketching in my own time," he explains. "I didn't feel it was likely that one engineer could come up with something better than the companies that make millions of these units every year."

But Roger had come up with a better idea. Inspired by a presentation on how to develop ideas, Roger refined his theoretical design on the train journey home. Roger entered the idea for a global Arup Ventures competition, and won the first prize. "It was obvious from the start that Roger's idea could solve something that was giving a lot of our clients a headache," says Arup's ventures manager Ralph Wilson.

The ceiling-based Hybrid Fan Coil Unit offers the flexibility of a fan coil system with the low energy consumption of a chilled

beam. "It costs the same or less than conventional systems but needs around 300mm less ceiling height," Roger explains. "In an average 12-storey building, this can result in a whole extra floor without increasing the overall envelope height – a major benefit for developers."

Arup partnered with air conditioning manufacturer Airedale and fan manufacturer ebm-papst to develop prototypes and sell the finished product.

Roger says that none of this would have been possible without Arup's support: "This isn't something I could have done outside Arup. The initial design reviews with colleagues from across the firm gave me the re-assurance that the product would sell, and the ventures initiative gave me the support I needed to nurture it. So I'd say to anyone else in the firm who has an idea: 'You can do this too.'"

The Hybrid Fan Coil Unit is due on the market at the end of March 2017, and three demonstrator units are already installed in Arup's London offices.



If you'd like to know more about its benefits and be kept informed about its launch, please contact ralph.wilson@arup.com



Improving on traditional construction

By taking traditional construction systems, adapting and improving them with modern engineering and testing, we are creating buildings that are safer, seismically resistant and more sustainable, using local materials like cane. Our project creating housing for low-income communities in El Salvador won a 2015 IStructE Award.



Sainsbury Wellcome Centre

Our engineering and consultancy helped to create a world-class neuroscience research centre in London's Fitzrovia – the Sainsbury Wellcome Centre. The flexible, adaptable, and resource-efficient space fosters a culture of innovation and collaboration by encouraging scientists to interact and share ideas.



oneTRANSPORT

Imagine your phone telling you to stay in bed because the traffic is terrible, or that the quickest way to get to work today is to hop on your bike. We're creating an open-source ITS platform through the oneTRANSPORT project that shares data using internet-of-things technology. It will help create new information services and tools that make getting around easier.



The Smile

An installation for the 2016 London Design Festival, the Smile combines the latest innovations in timber – cross-laminated timber, self-tapping screws and CNC machining – to show how rapid prefabrication is revolutionising timber construction. Engineered by our Advanced Technology and Research team, the Smile is the culmination of 15 years of research between Arup and the American Hardwood Export council into the use of hardwood in construction.

Image © Dav Stewart and Jon Cardwell



Picturing

Visual highlights from some of

innovation

our most innovative projects



Mobile data collection

The mobile data collection app we've developed for geomorphological surveys has revolutionised field data collection, cutting costs by up to 60% and replacing paper maps in surveys. It's already been put into action with clients including SEPA and Yorkshire Water.



Reflex Super Comfort

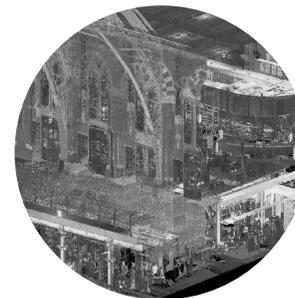
Launched in partnership with world-class lighting manufacturer iGuzzini, the Reflex Super Comfort eliminates glare and maximises useful light. Ideal for large spaces, it has already been used in Hong Kong International Airport and Singapore Changi Airport.

Image © Marcel Lam Photography



Highbury substation

Our idea for an alternative cooling system at National Grid's substation in Highbury, London, will harvest enough low-carbon heat for the equivalent of around 200 households. This will reduce CO2 emissions by 34 tonnes every year. It also helped our client secure planning permission for the substation.



LiDAR technology for old buildings

New technology is improving the way we assess and preserve old buildings. LiDAR measures distance using laser and can produce accurate 3D point clouds of historic structures. This enables us to better study, understand and repair existing buildings than would be possible using old records or conventional survey techniques.

FEATURE FOCUSING ON SAFETY

© Shutterstock

CAMERA 1

CAMERA 2

4/1/14

19:00

4/1/14

19:00

FOCUSSING ON SAFETY

CAMERA 3

CAMERA 4

4/1/14

19:00

CAMERA 1

CAMERA 2

4/1/14

19:00

4/1/14

19:00

Innovations in security camera technology are helping to create safer cities

CAMERA 3

CAMERA 4

4/1/14

19:00

4/1/14

19:00

From Queen Elizabeth Olympic Park in London to the city of Lahore in Pakistan, Arup's clients are using new camera technology to ensure public safety and security. And they're doing so in a way that doesn't intrude on people's privacy.

"The technology that exists today means that security cameras can be part of a much more reliable range of tools," says Simon Brimble, an associate director at Arup who specialises in physical security. "Cameras were once purely for supplying evidence to prosecute people who committed offences. Now they help organisations to keep crowds safe. They assist with emergency evacuations. Body cameras are being used to protect both the police and members of the public. They can even help find missing vulnerable people."

New possibilities are opening up as cameras become capable of recognising individual people. "Cameras can now recognise gait as well as faces," explains John Freeman, a senior security consultant at Arup. "The camera system learns how you walk, so even if it can't see your face properly, it can still identify you."

John's colleague, security and business continuity consultant Nick Goldby, reflects on the advances made by camera manufacturers. "Analytics on cameras can now identify crowd movements," he says. "So, for example, a camera could identify someone moving against the flow of people leaving a stadium and trigger an alarm because that behaviour is unusual, and potentially suspicious.

"It's now possible for cameras to identify suspicious objects that could pose a bomb threat, and automatically find and track the person who left them behind. They can highlight when people move things

that shouldn't be moved – such as security barriers. And they can identify people in wheelchairs and tailor electronic wayfinding boards for them."

The cameras themselves have now become information and analytics servers – or, as Simon puts it, "the eyes and the brains" sending messages back to a control room. In turn this supports new business functions and cause-and-effect planning.

The latest cameras are even capable of controlling access to buildings, as John explains: "We're working on a new development in the heart of the City of London at the moment. The client wants an access control system where all users have to do is approach a line of security turnstiles. The system recognises the people who are authorised to enter and opens the gate for them."

Increasing automation like this has the benefit of freeing up resources, our experts point out. Gone are the days of camera operators trying to manually monitor multiple screens. Today's technology can take care of spotting problems, leaving operators to initiate the appropriate response.

As cameras have become more powerful, typically fewer cameras are required to monitor an area than five or ten years ago. Similarly, Simon points out, a camera mounted on a drone can now do the job of a crewed helicopter.

The key to making the most of the technology, agree our experts, is for clients to have a clear idea of what they want to achieve. "You need to apply the right technology in the right place for the right reason," says Nick. "If you just stick it in because it's available, it may not be effective.

With the right checks and balances in place, our specialists believe, new security camera technology has the potential to create even safer cities.

Cameras were once purely for supplying evidence to prosecute people who committed offences. Now they help organisations to keep crowds safe.

Using technology to create a safer Lahore



Akbar Nasir Khan
Punjab Safe Cities Authority's
chief operating officer

The Lahore Safe City project, on which Arup is advising, is part of a Punjab-wide initiative to create secure, peaceful and prosperous cities by harnessing modern technology.

“The project combines audio-visual, data centre and LTE-A communications technology,” explains Akbar Nasir Khan, the Punjab Safe Cities Authority’s chief operating officer. “Its goals are to aid counter-terrorism, manage traffic intelligently and enable government agencies to respond to emergencies in an integrated way.”

So, for example, traffic police can use tablets to access databases of suspected terrorists. If an officer stops someone for a traffic offence, they can use facial recognition technology to see if they’re wanted for anything else. Similarly, number-plate recognition cameras enable officers to identify stolen vehicles without leaving the safety of their own cars.

But the technology isn’t just for law enforcement; it’s also designed to improve personal safety. With this in mind, particular attention has been paid to areas of the city frequented by women, whose safety has been a

major issue in Pakistan in recent years.

All this requires a big technological leap. “Many of the things we’re introducing are very new,” says Akbar. “And we’re lucky that our solutions provider, Huawei, is very willing to innovate. For example, Arup is helping us to create a video centre capable of handling thousands of simultaneous feeds – more than most other centres of this kind, around the world.”

Realising this vision of integrated technology has required political will and public support. Akbar points out that the project responds to people’s demands for the government to make use of technology that is increasingly widely available. He also believes the support of the Punjab Chief Minister, Mian Muhammad Shehbaz Sharif, was vital to the success of this project.

Future advances in technology, Akbar believes, could see connected security systems stretching across city boundaries making Pakistan an even safer place. This would require integrated systems supported with high-speed, private fixed and mobile 4G networking to transport voice, video and data.

The cameras keeping Queen Elizabeth Olympic Park safe

Arup’s security consultants have worked on Queen Elizabeth Olympic Park since before the London 2012 games. With their help, the London Legacy Development Corporation’s head of security, Tony Tolley, is embracing the latest technology.

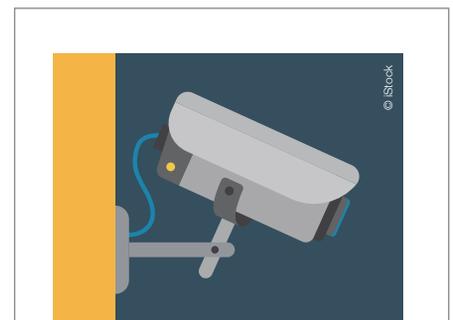
“We use technology to create intelligence-led teams of people who can be proactive and react to incidents more effectively,” explains Tony. “The latest technology enables us to cover a large estate effectively.”

Cameras with enhanced analytics help manage large crowds as they pass through pinch points in the park, forewarning operators if anywhere gets too busy. They deter antisocial behaviour – spotting people spraying graffiti tags, for example. And they even monitor flooding from the River Lea and alert Tony’s team when areas become flooded and need to be closed to the public.

This doesn’t mean the Park is bristling with cameras, Tony explains. “High-level cameras mounted on top of the ArcelorMittal Orbit enable us to monitor a lot of the estate – just under a square mile – with just a few cameras. Through technology-engineering we can minimise the equipment we need.”

Advanced camera technology also ensures that Tony and his team can work in harmony with the Park’s wildlife. “Light levels in the north of the Park are kept low at night for the benefit of animals such as bats and newts. We’re able to use new starlight or night-vision cameras to monitor these areas without disturbing the wildlife.”

With this sort of technology complementing high-visibility manning, Queen Elizabeth Olympic Park has become the first such public space to be awarded the police’s Secured by Design standard.



AN ENABLER FOR CHANGE

It’s clear that CCTV can now genuinely be seen as an enabler for safer cities when combined with new emerging transmission technologies. As our specialists highlight, it is essential, though, to always undertake a privacy impact assessment to ensure the application is proportionate to the need.

Society asks a lot of roads, railways and other infrastructure. They must cope with the demands of burgeoning populations, become resilient to the effects of climate change and prepare for radical shifts in mobility such as driverless vehicles. And they must do it all from squeezed public finances.

This is where innovation comes in – with its potential to improve performance and efficiency. ‘Wi-fi roads’, for example, could automatically update drivers on congestion or closures. Radar could detect breakdowns quickly. Intelligent robots could repair and maintain rail infrastructure.

To make such ideas a reality, our experts argue, a different approach is needed to consistently turn potential innovation into real-world solutions.

A strategic approach to innovation

“There are pioneering examples of innovation on high-profile megaprojects,” says Savina Carluccio, an Arup engineer who specialises in advising infrastructure organisations. “We can learn valuable lessons from these – lessons that are very much applicable across the infrastructure sector.”

In the UK, Arup client Crossrail has been widely lauded for demonstrating that innovation can be managed systematically and collaboratively. Its Innovate18 tool enabled suppliers to share ideas for innovation throughout the programme, and provided funding for the strongest ideas, such as using drones for construction.

“What we learnt from the Crossrail example,” says Savina, “is that true innovation requires a strategic commitment, high-level leadership, proper financial support and an open, collaborative approach from large infrastructure organisations.”

How can the sector embrace innovation in this way? “Putting innovation at the heart of the client organisation through committed leadership is key,” says Savina. She points to the strategy that transport body Highways England has created, with Arup’s help, for a £150m ring-fenced capital spend on

innovation over the next five years.

“The money is important but it’s only an enabler, part of a broader picture. And it’s not just about technology, either. Innovation can take many forms – from products and processes to behaviours and new ways of working.”

Highways England’s innovation director Richard Porter explains how an organisation can make this happen. “A strategy gives you a long-term goal and sets people’s expectations,” he says. “The challenge is transferring this into a workable, trusted system that people feel they can opt into.”

As Richard points out, it’s all about people. “Yes, innovation is about good ideas. But it’s people who drive the adoption of those ideas. So any innovation strategy has to focus on how people will adopt new ideas.”

Taking an open approach

“Being open and transparent – with employees as well as suppliers – is vital to get people on board,” he continues. “You need to do things like allowing people to submit ideas of any kind and giving them feedback about how they could take it forward.”

For its part, Highways England will work with supply chain partners, technology specialists and the automotive industry to trial new technologies that could make journeys safer, more reliable and better informed.

A trial connected corridor or ‘wi-fi road’ will see cars and infrastructure connected wirelessly to the internet. Drivers will receive news of road closures, congestion warnings and information about alternative routes.

Radar technology on motorways and in tunnels will be trialled to see if it can improve the way breakdowns are detected. Highways England will also explore the use of sensors to monitor the condition of road assets remotely.

“In such projects it’s the speed of innovation that’s crucial,” says Richard. “Rather than think too much about risk and

Putting innovation at the heart of the client organisation through committed leadership is key.

reward, I think it’s important to focus on how quickly you can propagate and iterate ideas,” he says.

“In order to make innovation happen however, Savina continues, “there should be an advantage for all parties involved. Procurement models have traditionally been innovation blockers. Using the right form of contracts would undoubtedly incentivise the supply chain to identify and deliver innovations.”

Embracing failure

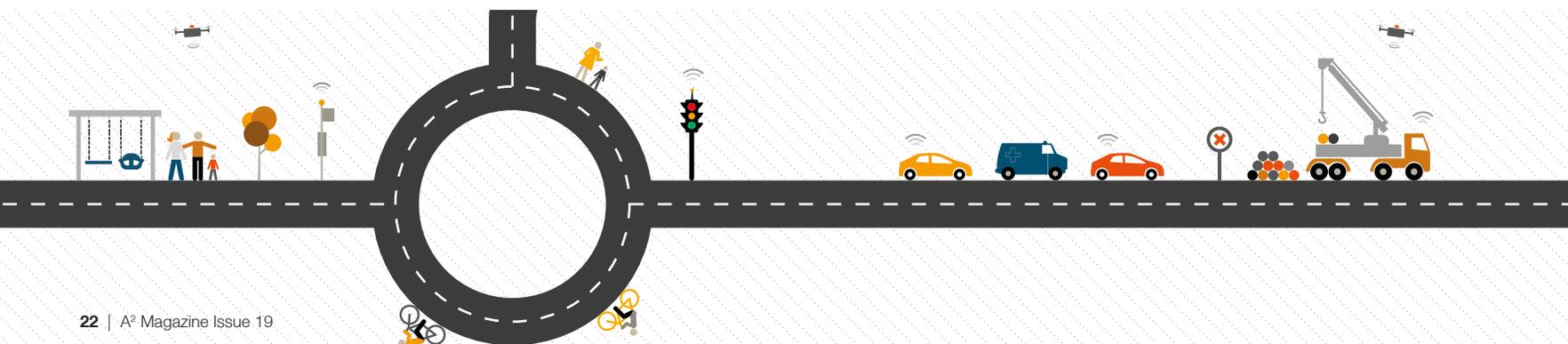
Of course, not all ideas will work and Savina highlights that it’s also important to embrace failure. “You can learn a lot from failures,” she says. “And failing fast is a very valuable skill – it’s good to kill ideas that aren’t going anywhere before spending too much time or effort on them.”

“To find out quickly if projects that sound risky, like solar roads, will work,” says Richard, “we can dedicate a little bit of time and money to them. Once we understand the business impacts, the partners we’ll need to work with and the return on investment, we can make a quick decision.”

Organisations and their leaders need to be bold enough to make these decisions. So an organisation’s people and culture are the final – vital – piece of the innovation jigsaw puzzle.

Fostering an innovation culture

“It’s important to develop a culture of innovation both between and within organisations,” says Savina. “This can mean bringing in someone specifically to lead innovation – someone with fresh ideas and a remit to be more daring. In the UK, High Speed Two (HS2), like Highways England,



has appointed a head of innovation.”

“Everyone needs to buy into the strategy and help make it happen,” says Richard. “So everyone needs to feel they’re part of something. They need to feel free to challenge the rules – including everything from construction standards to organisational rules.”

He also argues that having a strong continuous improvement process within an organisation is the foundation of successful innovation: “You need both. Any organisation that wants to embed innovation has to take continuous improvement very seriously. If you can’t make day-to-day improvements, you won’t be able to tackle more radical innovations.”

Innovation and delivery of new infrastructure

It’s clear that Crossrail has left a great legacy for managing and delivering innovation for large infrastructure projects. The next generation of flagship infrastructure projects such as HS2, for which Arup is providing multidisciplinary services, are striving to build on this and make innovation the norm.

“Infrastructure projects have a complicated mix of clients, consultants, supply chain members and other stakeholders,” Savina says. “So it takes real vision to embed an innovation-led approach to delivery, one that truly goes beyond business-as-usual.”

“To innovate, clients, designers and delivery teams need to start thinking creatively at the concept stage. They need to embed innovation systematically by bringing in good ideas – whatever the source may be – at all stages of the project lifecycle.”

Good ideas should travel

Ultimately, Savina and her colleagues at Arup believe that innovation is something the infrastructure sector should be hearing more about: “Good ideas should travel,” she says. “The sector needs to share success stories and show that people and culture are instrumental to innovation. Only then will it make innovation happen more widely – to the benefit of everyone.”

HOW TO EMBED INNOVATION



“Baked in, not bolted on”

How does an organisation like HS2 put innovation at the heart of its work? We spoke to HS2’s head of innovation Iain Roche to discover more

“My job is to drive the innovation agenda from the top,” explains Iain, “to ensure the organisation is being aspirational enough and to make innovation accessible to our own staff and our supply chain.”

This, then, is an all-encompassing approach to innovation. “The innovation team is here to facilitate and catalyse innovation across the programme,” says Iain. “Our aim is to help HS2 achieve, or even surpass, its strategic goals and objectives. That means innovation isn’t just about technology, it’s also about benefits in health and safety, sustainability, design, passenger experience, robust operations and excellence in delivery and construction.”

HS2 is building on best practice in innovation, sharing knowledge with

organisations like Crossrail, Heathrow Terminal 5 and others. Indeed, Iain describes Crossrail as one of the best examples he’s seen of a well-structured innovation strategy.

“In Crossrail, innovation has been led from the top. There are clear objectives and structures, such as the Innovate18, to help manage ideas from all levels of the supply chain. However, if there’s one lesson from Crossrail it’s that innovation needs to be a focus from the start of a major project.

“By bringing innovation into the programme early, HS2 ensures it’s baked in, not bolted on – it’s absolutely critical to the delivery of the programme. This provides opportunities for innovations to influence critical design decisions at an early stage and for us to engage our supply

chain in the process.”

As for the outcomes of this approach, Iain points to HS2’s use of building information modelling (BIM) as just one example. “At HS2, we’re investing heavily in our BIM capability. Today this enables us to share our data and explore the art of the possible. In the future, the model will inform construction and, with as-built data, enable us to implement a more proactive maintenance regime.”

To organisations looking for innovation to deliver these sorts of long-term and wide-ranging benefits, Iain has this advice: “It’s not just about having a process to capture ideas. It’s not just about creating the right culture. It’s not just about investing money in innovation. It’s about all these things working together.”

Self-heating Materials

Facial Recognition

Autonomous Vehicles

ANTICIPATE AND ALIGN

How foresight enables innovation

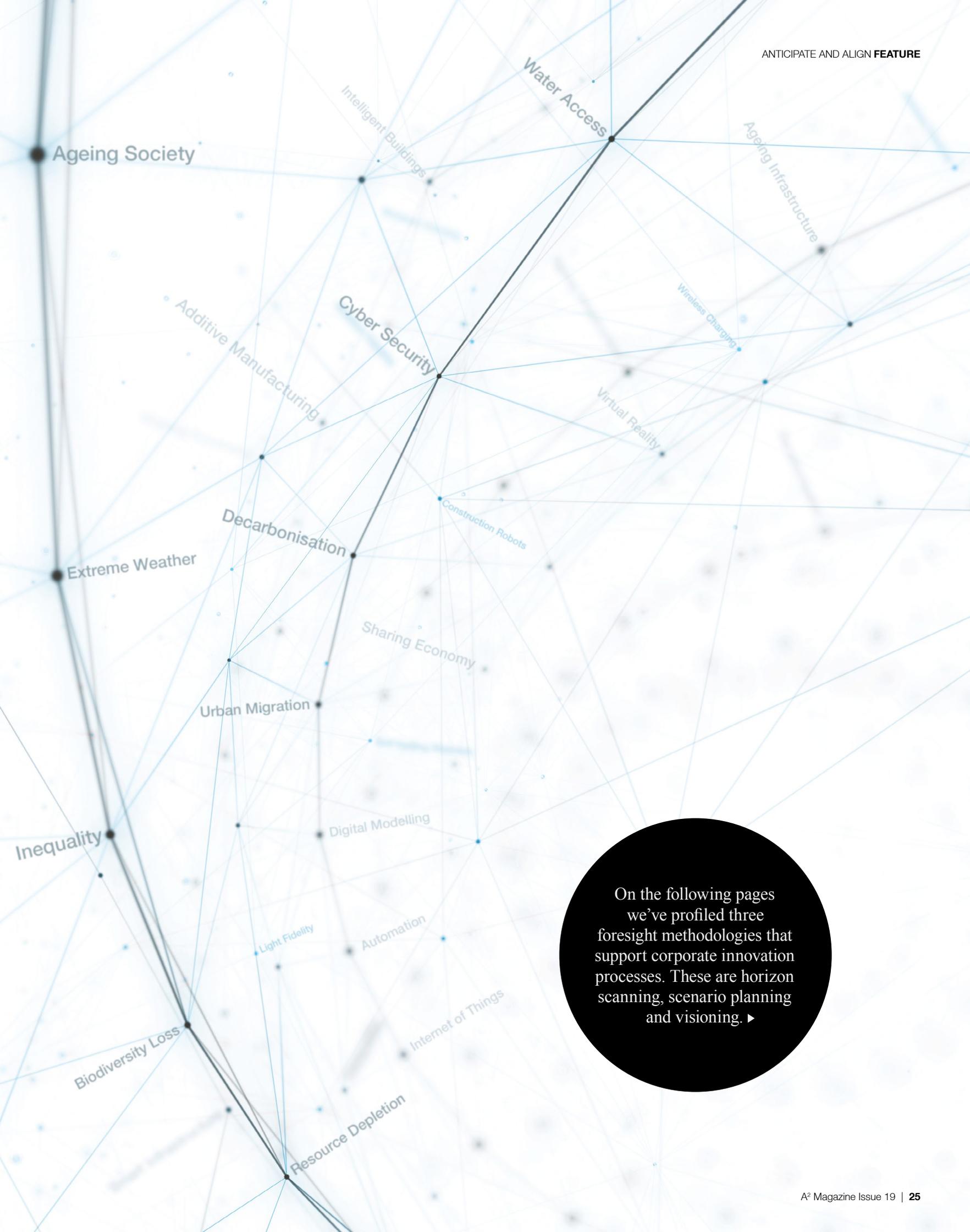
Philosopher Heraclitus of Ephesus famously said that change is the only constant. This continues to hold true, says Marcus Morrell, an associate in Arup Foresight + Research + Innovation, our internal future-focussed think tank.

“The world is evolving faster than ever, largely due to technological advances, and the marketplace is becoming more complex. Against this backdrop, innovation that aligns with future-shaping trends has the best chance of success.”

This is where foresight comes in. Foresight helps organisations understand and anticipate change – enabling business to adapt and supporting successful innovation.

E-mobility

Smart Infrastructure



On the following pages we've profiled three foresight methodologies that support corporate innovation processes. These are horizon scanning, scenario planning and visioning. ▶

Horizon scanning

MEGATRENDS

These are the global forces that affect society as a whole – such as climate change, population growth and urbanisation. Megatrends are far-reaching, sustained and relatively certain. They are often the result of a complex interplay of many different forces – social, technological, economic, environmental, and political.

The Drivers of Change cards are just one output from our ongoing horizon-scanning activities. They help Arup’s businesses and clients identify and explore key factors likely to affect the world. Each informational card describes a single driver. A factoid and rhetorical question on one side are backed up by a more detailed exploration of the trend or issue on the reverse.

Opportunities in business are increasing in response to climate change mitigation measures. These include investment in non-fossil-fuel energy generation and energy-efficiency technologies.

Drivers of Change, business opportunity card

Discover more at driversofchange.com/tools/doc

Cities are reliant on imported food to feed their growing populations, and food security and under-nutrition are increasingly urban issues. In many cities the urban poor spend 90% of their household income on food.

Cities Alive, food security cards

Download the Cities Alive cards at driversofchange.com/projects/cities-alive-cards

SECTOR TRENDS

These are the trends seen in specific regions, geographies, industries or businesses – smart and seamless mobility in the transport sector, for example. A better understanding of sector trends helps stakeholders explore and prioritise issues shaping the future of their industry. They can develop strategies, products or services that respond to new and emerging opportunities and challenges.

Our sector-specific foresight programmes engage executives and business units in targeted conversation on how trends will impact aspects of a business, and what the associated implications might be. We support this with dedicated trend cards and engagement tools. Our Cities Alive cards, for example, help citizens, planners and officials to prioritise and explore 100 trends and issues shaping cities.

Capable of accommodating 24,000 cubic meters of water when flooded, this design concept for a floodable urban park in Copenhagen combines climate-resilient city infrastructure with landscaped public space.

Floodable public park concept, captured on Arup Inspire

WEAK SIGNALS

These are the seeds of change that could develop into full-blown trends over time. Today, driverless vehicle technology might be considered a weak signal. It offers intriguing possibilities, but its true potential and impact remains uncertain.

Arup Inspire, our intranet-based database of weak signals, captures innovation case studies from across the globe. It is available for our staff to use, to inform design, innovation and planning processes. We also create and populate white label versions for other organisations to help them innovate.

Scenario planning

Scenarios explore a range of different possible futures. Based on quantitative and qualitative information, they investigate how complex systems may evolve over time. Scenarios challenge the tendency to favour the business-as-usual future and encourage exploration of the alternatives.

Our Future of Urban Water initiative with Sydney Water explored four scenarios for water utilities in 2040. Using Sydney as a reference city, the scenarios envisaged varying degrees of centralisation and cross-utility integration. They each explored how social, technological, economic, environmental and political trends could shape the urban water future. The outcomes informed corporate planning and helped develop new methods for customer engagement.

Find out more at publications.arup.com/publications/f/future_of_urban_water

Water is about supporting our cities' resilience to shocks and change. It's about the ability of water resource management to support a city's growth. The scenarios we examined suggest that we cannot simply assume centralised planning, delivery and management of water services will achieve the best outcomes.

Kaia Hodge, Liveable City Programs manager, Sydney Water

Visioning

What optimal state should society aim for? What shape should an organisation seek to achieve? What are the ideal outcomes for a project? A vision ensures that organisations and large capital projects work towards a common goal. Visions provide strategic direction and help foster collaboration, creative thinking, design innovation and shared commitment.

Our visioning workshop enabled Hertfordshire County Council to identify challenges and opportunities from now until 2050 as it sought to update its transport strategy. The process helped council officers redirect their original strategy to develop a broader vision for a sustainable future. This vision was used to engage residents and businesses in a discussion about the county's future. The new strategy is based on walking, cycling and public transport, and on highways projects that cater for a variety of users.

The workshop exercise enabled us to identify and prioritise the drivers of change that will shape Hertfordshire up to 2050, focussing attention to the issues that are going to matter to the next generation.

Andy Summers, Hertfordshire County Council – Transport Policy and Growth



Marcus Morrell is an Associate with Arup's Foresight + Research + Innovation team, and is responsible for foresight activities in the UK. To learn more about how foresight can help your business, or to discover more about Arup Foresight + Research + Innovation, visit arup.com/services/foresight or driversofchange.com or e-mail foresight@arup.com

THE NEXT BIG THING

Arup's Chief Information Officer Stephen Potter talks to Stuart Marks, founder of corporate innovation specialist L Marks, about how large organisations can shake up their operations by running accelerator programmes with start-up companies



Stuart Marks
L Marks

[SP] I've been at Arup for two years now and I'm struck by how innovative the firm is, but I'm keen to explore how other organisations foster and scale new ideas. You organise accelerator programmes, which bring corporates together with start-ups working in relevant areas. Why is a start-up accelerator a good way to innovate?

[SM] The corporate landscape has changed beyond recognition in the last ten years. The internet has made it a lot easier for big business to be disrupted by new competitors, while big businesses themselves find it hard to change rapidly and innovate in response.

Start-up accelerators provide a way for large businesses to work with bright companies that approach things from a completely different perspective. It's not the silver bullet for corporate innovation, but it gives the organisation a practical way to make a transformation.

[SP] My field is IT, and it's often said that today IT has to be bi-modal. It needs to use established, reliable technology but it also needs to explore innovative, emerging opportunities. I can see how hosting start-up companies provides a similar bi-modal approach, but how exactly does it work?

[SM] It starts with what we call a category identification session, where we ask stakeholders in the host organisation what things they would like to do differently. We then scout for start-ups working in these areas, ask them to apply for the programme, and select the final group.

JLAB – the John Lewis start-up accelerator

John Lewis has been running its JLAB start-up accelerator with L Marks for three years. Each year, five start-ups are selected for a 12-week programme to help them build their businesses and forge a deeper relationship with John Lewis. One of JLAB's successes is start-up company DigitalBridge. Its visualisation tool could soon allow John Lewis customers to see what their home-decoration products would actually look like in their own rooms. This 'imagination gap' is currently a major problem in the interior design market.

[SP] You've worked with John Lewis on its start-up accelerator, JLAB. Like Arup, John Lewis is an employee-owned organisation. How does a start-up accelerator fit with the philosophy of employee-ownership?

[SM] I don't think John Lewis' ownership structure was the defining factor in its decision to use a start-up accelerator. But it did want to work with start-ups that shared its ethos.

And something that was different this year was the Partners' Choice Award, which gave staff a say. This saw 400 John Lewis partners vote on their favourite start-up, and room-visualisation start-up DigitalBridge was the clear winner.

[SP] That's interesting, because I know Arup's venturing team [see page 8] are very careful to ensure that the innovations they help bring to market support the firm's principles.

Of course, Arup works in a very different market to John Lewis. How would you see your approach working in the built environment sector? Do host companies have something in common in terms of how they're looking to create value?

[SM] The common thread between our clients is that they've usually talked a lot about innovation, and tried to innovate in the past – with mixed results. They're usually worried about their industry being disrupted. And they're usually curious about what might come out of a process like this.

It's hard for me to comment on the built environment specifically without knowing more about the sector, but I'd say that start-up accelerators can provide the first rung on the innovation ladder. They provide an opportunity for organisations to improve in areas they're not good at.

[SP] I see, so it's a learning process for the corporates as much as the start-ups. Does this mean you believe you can measure success in terms of more than just finding start-ups for corporates to work with? For example, I know that when people at Arup come together to work on new ideas, they often say how much they benefited from the chance to learn from one another.

[SM] Yes, absolutely. At the end of the programme, following a final demo day, the host can procure services from the start-up, invest in it or even acquire the start-up. But there's more to it than that.

The process provides an opportunity for the hosts to look at their business strategy through the eyes of these start-ups. That's something they just wouldn't normally do.

OVE THE INNOVATOR

After a major exhibition at the V&A Museum showcased the work of our firm and its founder, we examine Ove Arup's legacy of innovation

When the V&A Museum in London wanted to create an exhibition season celebrating the importance of engineering in the twentieth century, it turned to Arup and our founder Ove Arup.

“There’s no better person to tell that story than Ove Arup,” says Zofia Trafas-White, the exhibition’s co-curator. “His ideas about total design revolutionised the discipline at the time. His vision of a unified and multidisciplinary approach – something that’s ubiquitous in practice today – was something that was very new and very unusual at the time.”

“This is what the exhibition, *Engineering the World: Ove Arup and the Philosophy of Total Design*, celebrated. Running from June to November 2016, it featured unseen archival materials from seminal projects such as the Sydney Opera House and Paris’ Centre Pompidou, as well as recent prototypes and digital animations.

There was even the chance to get up close to the valve-based computer that saved 10 years of manual calculations on the Sydney Opera House. Ove and his team used the computer to model the roof and analyse the structure of the iconic, but complex, pre-cast concrete shells. They turned a vision some said was unbuildable into reality.

Such projects are the result of an approach to business founded on a belief in shaping a better world. Arup deputy chairman Tristram Carfrae explains. “Ove studied philosophy as well as engineering and had a unique approach to how we should operate as an organisation and how we should serve society.”

“At its heart, engineering is about helping people live simpler, easier lives,” says former V&A Museum Director Martin Roth in his preface to our 2016 Design Book. “Its social dimension affects our quality of life, whether it is a new transport route that shortens a daily commute by an hour or two, or the building of a bridge that will

connect an isolated rural community to the world beyond.”

Ove also believed that to help society, the firm had to invest in people and treat them fairly. In what became known as his Key Speech in 1970, he wrote: “What I want to stress is the obvious fact that no matter how wonderful an organisation we can devise, its success depends on the people working in it - and for it.”

“Once he had chosen his colleagues and employees, Ove let go of the reins and placed an almost childlike trust in them.” Those are the words of Sir Jack Zunz, principal structural designer of the Sydney Opera House and former chairman of the Ove Arup Partnership. “He delegated responsibility quite naturally,” says Sir Jack.

Ove was also an innovator when it came to employee ownership, helping to create the structure of the firm that remains to this day. “This devolution of ownership has proved to be the keystone to the firm’s success and could not have been achieved without Ove’s total commitment,” says Sir Jack.

Today, the legacy of Ove’s total design approach and investment in people are still valued highly by our employees. “The thing I value most about Arup is definitely the people and the humanitarian attitude,” says Maria Montero, a senior consultant in our Madrid office. “It’s a very international environment to work in. I like the way Arup links technical and social aspects of projects – perhaps because Ove Arup was a philosopher who became an engineer.”

“The people who make up the firm – they are Arup,” agrees Bruce Tanner, our chief operating officer for Australasia. “The networks that you can develop and take part in are fundamental. Whatever you have to tackle, being able to do it with a great team of people who are passionate and enjoy their work is something special.”

Our 2016 Design Book, *Total Design Over Time*, is available now to buy or download from arup.com.



The principles of total design, which Ove Arup put in place, were revolutionary at the time. And they are as relevant now as they were when he started out some 70 years ago.

