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Smart' has been a buzzword for more than a decade. It has been used in connection with everything from the smart grid to smart metres, and smart infrastructure to a smart planet.

The conversation around smart is very often technology-based. But being smart is ultimately about the benefits technology can bring. At Ramboll we believe that to be truly smart, technology must have added value for people and society, for example improving resource-efficiency and liveability.

We experience that an increasing number of cities, communities and society need help in focusing on the value technology provides. How can we use technology to reduce congestion and waste less resources? Or build better buildings and more efficient energy systems? How can technology make our cities more convenient, more sustainable and more liveable?

This issue of Response examines how we can build not just a smart society, but a smart, sustainable society.

For instance, in some cities smart mobility is not achieved simply by replacing private cars with driverless vehicles. They might want to reduce the number of, and dependence on, vehicles while creating more space for cycling and walking. This in turn reduces pollution and CO2 emissions, decreases noise and reclaims the city as a place for people.

In other cities, a different approach may be required – where technology is not necessarily the prime solution and instead the focus is on urban planning.

The important thing is to understand that each challenge requires a unique solution dependent upon local conditions. Our approach can also be applied to buildings, infrastructure, water and energy just to name a few. Solving these challenges can also be cost-efficient allowing them to be environmental, economically and socially sustainable.

Enhancing technology and creating a smarter planet is not the goal in itself. It is the means in which to achieve a better society – and even a better planet.

Enjoy your reading.

Jens-Peter Saul
Group CEO
THE TRULY SMART SOCIETY IS ABOUT PEOPLE

The smart use of technology is not a goal in itself but a means to achieve improved liveability and sustainability.

By Andrew Somerville and Michael Rothenborg
In recent years, the notion of the smart city has become a well-developed narrative. At the heart of this lies the belief that technology can make societies more liveable, improve living conditions and help create a sustainable and resource-efficient future. In short, shape a better world.

Already, intelligent buildings can monitor our preferences to optimise energy efficiency and comfort. Data can be harvested to help us choose personalised transport options and autonomous vehicles can help hospitals cut costs and improve efficiency.

But it is important to remember the human element if we are to create a truly smart society, stresses the research paper ‘Towards a smart society’ by the Big Innovation Centre in the UK. Professor William Powrie, from the Faculty of Engineering and the Environment at the University of Southampton, agrees that taking the human factor into consideration should be the central tenet of using smart technology in successful urban planning.

“I’d advocate reducing consumption of energy and resources, and hence CO2 emissions, in a way that makes people feel happy and content,” he says.

Smart and sustainable
Ramboll believes that a society can only truly be considered smart if we combine the benefits of technological innovation with an emphasis on sustainability and liveability. Factors such as improved infrastructure, better mobility, intelligent buildings, digital networks and clean energy mean even more when they improve people’s lives.

In other words: smart is not a goal in itself – but the means to improve liveability and to achieve a sustainable future.

Henrik Stener Pedersen, Director for Social and Economic Impacts at Ramboll, underlines that to be considered smart, a society must improve the quality of life for its citizens in terms of better health and security, education, work, and quality of life.

“It is also crucial to ensure the sustainability of a city not just economically and environmentally but also socially. This in turns makes the city more attractive by increasing its competitiveness and efficiency and making it a desirable place for living and business development,” he states.

From smart buildings and hospitals, to more sustainable transport and efficient energy, we highlight over the following pages (6-33) how Ramboll promotes smart, innovative technology that aims to make society more sustainable and liveable.
As cities continue to grow, urban transport systems are increasingly feeling the strain. To improve mobility without increasing air pollution and CO2 emissions, cities need transport systems that are holistic, integrated and utilise innovative technology. In other words, smarter.

By Andrew Somerville

On a cold but sunny day in Helsinki, Jukka-Pekka Pitkanen, Global Division Director for Smart Mobility at Ramboll Finland, is on his way to his next meeting. He opens up an app called ‘Whim’ on his smartphone and with access directly to his calendar, the app knows exactly when and where he is heading.

With the current location determined by GPS, he is instantly presented with a range of transport options - from tram and bus to private car and taxi.

As many of us who live in them know only too well, moving around crowded, congested cities...
can be a challenge. And things are only set to get worse, with nearly 70% of the world’s population projected to live in urban areas by 2050, according to the UN.

The good news is that as cities and their infrastructure become more connected, the ability to make transportation systems that are efficient, sustainable and smarter is increasing - if planned and implemented in the right way.

At the heart of this lies the concept of smart mobility. This involves combining intelligent transport systems, which combine sensing technologies like cameras, radar and traffic counters, with the use of data from the internet and smartphones. Smart mobility is a central focus of Ramboll’s approach to making cities more liveable and sustainable, and takes a holistic view of transport - from maximising the use of precious public space to more sustainable infrastructure such as bike paths, smart parking, car sharing and better traffic information.

But smart mobility is not just about technology, emphasises Jukka-Pekka Pitkänen. “Technology is, of course, at the core of this. But mobility in cities does not become smarter just because the technology is smart,” he says.

“There are also plenty of more immediate ways of increasing mobility and making it more sustainable. This can be everything from more efficient traffic flow to better use of existing transport infrastructure and increasing the sharing of modes of transport.”

On the move in Helsinki
Helsinki is arguably one of the smartest cities in the world right now when it comes to mobility. Jukka-Pekka Pitkänen is running late and so reluctantly opts to take a taxi. He barely has time to look up before it arrives, and ten minutes later pulls up at his destination and steps out without paying. Because he is a subscriber, the app automatically deducts the fare from his account.

TAKE A WALK ON THE SAFE SIDE
Smart mobility is not limited to transport users. In Finland, the Viasmart system developed by Ramboll is in use in over 160 cities. Viasmart is a computer programme that evaluates the traffic risk for pedestrians and can help determine the best walking route based on road attributes and traffic features.

The system is used by schools to determine the safety of routes for students who walk to and from home. In Finland schools are not obliged to provide bus transport for schoolchildren if they live under three kilometres from their school - unless the route is deemed too dangerous. As Aino Mensonen, Service Manager for Digitalisation and Innovations at Ramboll Finland explains, “the challenge for school authorities has been how to evaluate this. We made a mathematical model that uses 12 parameters to measure the risk on any given route - such as the age of the child, the width of the footpath and street lighting in that part of the city and so on.”

Aino Mensonen envisages Viasmart being utilised in scenarios other than schools. “Road administrators can use it to determine which are roads are ‘black’ and then act accordingly,” she says. “And it can help traffic planners at Ramboll and within city authorities improve the design and planning of pedestrian crossings, lighting etc.”
bank account and it’s significantly cheaper than indicated on the taxi’s readout.

As it turns out, Jukka-Pekka Pitkänen’s destination is the head office of the company behind the Whim app, MaaS Global. Begun only two years ago, the Finnish company is quickly gaining international recognition as its customer base expands and investment increases.

The Netflix of transportation
The concept of MaaS (Mobility as a Service) was born out of frustration of not being able to find viable and integrated transport options. “As a business traveller I might want a fast service in all the countries I visit, while as a family with kids living in the suburbs I might want something else,” explains Kaj Pyyhtia, co-founder and Chief Customer Experience Officer at MaaS Global. “Providers often push out transportation, saying to people, ‘catch me if you can!’ That’s how a lot of transportation is operated and planned. You put up a schedule and then wait.”

MaaS aims to solve this by combining all the available transport options, such as taxis, public transport, cars and even bike share, into a single mobile service. Consumers can buy the exact transport options they need through the Whim app, either as a one-off purchase or on a subscription basis.

Crucially, MaaS involves the flexibility to use all modes of transport, even cars. “To ensure that the customer will use MaaS, we have to have neutrality – we allow everybody and all transport options,” says Kaj Pyyhtia. “Changing people’s behaviour is the hardest thing when it comes to the car. But car ownership is falling among the 18-25 age group and we have to offer an experience on par or better than owning a car. The dream used to be open highways, now we want to provide an open world – without the need to own anything.”

City support
Having the support of the city has been a major factor in the success of the MaaS project in Helsinki. According to Heikki Palomäki, a transport planner for HSL (Helsinki Regional Transport) who works closely with Ramboll in Finland, it is important that transport users all have the same options available to them.

MASS FACTS
- MaaS has recently launched in Birmingham in the UK.
- Launching in Antwerp, Belgium in May and aims to go live in a further eight cites this year.
- Has ambitions of operating in 60 countries or 100 cities in five years.
- 40,000 registered users and thousands of monthly subscribers in Helsinki.
- 70% of Whim users in Helsinki travel by public transport.

“Changing people’s behaviour is the hardest thing when it comes to the car.”

Kaj Pyyhtia
Co-founder, MaaS Global
Improving public transport and easing traffic congestion is one thing. But how do we ensure that essential services such as emergency vehicles can operate quickly and safely when called upon in a busy, congested city?

In Finland, Ramboll has developed the HALI Always Green system which automatically provides a green light for emergency vehicles without any pre-planned routes. Already implemented in two cities, the system is now being piloted in Helsinki, a project that is not without challenges as Sami Lappalainen, Senior Fire Marshall at the Helsinki City Rescue Department explains: “The system works by GPS where the fire engine or ambulance sends a signal so we know its exact movement and location and as it approaches an intersection, the traffic light automatically detects it and changes to green. However in Helsinki, trams have priority and we also have about 500 traffic lights, so this will take about five years to implement.”

While HALI helps reduce the time it takes emergency vehicles to reach the scene by 10%, it also vastly improves safety. “During that last ten years there have been 52 car accidents involving emergency vehicles,” says Sami Lappalainen. “So this new system is good for us. It’s all about safety. For us and road users.”

Since the introduction of the system in Eastern Finland, there have been zero accidents.

“Everyone needs mobility in some ways. If you feel you are not equal to those who own a car, then that’s wrong. And the same if you have a car and you’re not able to use public transport where you live. The integrated approach like MaaS makes being mobile easier so you don’t need your own car.”

However, he cautions against the over-reliance on vehicles - even if they are autonomous. “Public organisations need to consider the impact of AVs (autonomous vehicles) so that they do not become too desirable. Because if you change your car to an AV, then there will more traffic. Here you could use pricing to ensure this doesn’t happen,” he says.

**Increased public transport use**

Ramboll has been instrumental in the early success of MaaS, preparing business plans and providing extensive planning expertise, a vital element of the MaaS concept. “We don’t operate any of the fleets ourselves,” says Kaj Pyyhtia. “We are 100% reliant on the goodwill of our partners and we engage with officials and policymakers - unlike some companies who just launch themselves without consultation.”

This effort has paid off handsomely in Helsinki where more than 70% of Whim users now travel by public transport. “The primary promise we make is hassle-free transport, so you don’t have to think how to get from A to B. We take care of it,” says Kaj Pyyhtia. “We can’t unclog the congestion in a city immediately because we use what already exists - but we are making more efficient use of it.”
It is no surprise that the concept has been met with some scepticism: sending people through a giant, low-air-pressure tube at over 1,000 km per hour, much faster and in a more climate-friendly way than any commercial aircraft - and at around three times the speed of the Japanese Shinkansen and other modern bullet trains.

However, despite the far out sci-fi aspects, the hyperloop might be coming to a capital near you within the next decade - thus solving a lot of congestion problems.

Last year, Virgin Hyperloop One reported a speed record of 387 km per hour at its full-scale test track in the Mojave Desert of Nevada. This year the company has developed a full-scale pod prototype at the site (pictured).

Dubai, Saudi Arabia and several European countries have also expressed their interest, and KPMG and Ramboll have conducted a pre-feasibility study on the plans to link the Finnish and Swedish capitals with a tube that will cut the journey time for the 500-km trip to less than half an hour.

“Our expertise has been in rock engineering; civil engineering; environmental planning for a sub-Baltic sea corridor, a rock tunnel between the two countries; and two land-based corridors, one in Sweden and one in Finland,” explains Malcolm Sjödahl, Head of Business Development at Ramboll Sweden.

The joint conclusions of the study were highly promising, and Ramboll is now exploring a hyperloop test track section that would run from Salo towards Turku in Finland.

Folke Snickars, Professor Emeritus at KTH Royal Institute of Technology in Stockholm, Sweden, is among the positive independent experts:

“As a long-term researcher in the field I look positively on the project, which will take current train technology to a new level of innovation,” he says.
You walk into your office building. Interactive cameras (CCTVs) and the intelligent use of technology ensure seamless access throughout the day. The elevator automatically takes you to the floor where your desk is. When you arrive, the light is regulated to become a bit warmer or cooler - just the way you like it. And when you go to one of the flex rooms to do an important presentation, the temperature there also automatically adjusts to your needs - thus improving your productivity.

All over the world there is a growing demand to integrate technology into the built environment. Entrepreneurs and companies are becoming increasingly aware of the ways technology can enhance the energy efficiency of their assets - as well as the working environment - to reduce overheads, increase productivity and improve staff retention.

This emerging design discipline, known as 'smart buildings', encompasses more than software analytics and new technologies.

"It integrates design, mechanical and electrical building systems, sustainability and management consulting," emphasises Shonn Mills, Global Director for High Rise at Ramboll.
Singapore is a front runner

Singapore is a frontrunner in the building digitalisation movement – fuelled by country-wide initiatives like Singapore’s Smart Nation, which encourages the use of new and innovative technology in buildings.

“The Internet of Things (IoT) and smart technologies are changing the way we work and live at an incredible rate. We are designing and developing buildings today that will have a design life of 50-100 years,” says Shonn Mills. “With the accelerating change effect of technology, it’s an interesting challenge to try and create building solutions that will stay viable and relevant over the life of the asset.”

He points out that this is requiring engineers and designers to have new skillsets. Integrating smart technology into buildings increases efficiency and creates a new level of adaptability and space customisation that improves the user experience overall.

“Tall buildings should be designed as platforms to take full advantage of the latest and future smart technology. Thousands of smart sensors feed data to the integrated building management systems to allow the building to be adapted and optimised for improved energy efficiency, safety and security,” says Shonn Mills.

Smart investment pays off

Shonn Mills stresses that there should be proper communication between all parties, so that everyone understands why the data is being collected and used.

He adds that new digital solutions integrated with a building’s architecture can heighten comfort and productivity for building users as well as create new experiences and opportunities for collaboration.

“There is, of course, a premium to pay for implementing these solutions. But Ramboll carries out a cost-benefit analysis to ensure the payback period is within client expectations. This analysis also uncovers potential commercial benefits for our clients, as they can get more for their leases when their buildings are innovative and competitive – with a more efficient working environment,” Shonn Mills points out.

Ramboll has made a number of significant wins in Singapore in this new field. It has been appointed as a specialist smart buildings consultant to advise on integrating new technology with architectural and traditional building disciplines.

One of Ramboll’s clients, Chief Operating Officer Schirin Taraz from Woha Architects says:

“Woha sees digital solutions as a new frontier in the built environment. We carefully consider and incorporate smart technology into our new projects, where appropriate. Ramboll is one of our preferred smart building consultants and we use them to help us select the right technology for our projects to develop exciting bespoke integrations and new end-user experiences.”

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We use Ramboll for our projects to develop exciting bespoke integrations and new end-user experiences

Schirin Taraz
Chief Operating Officer, Woha Architects
Urban density is a pressing, global issue, and cities around the world are striving to keep their areas green, sustainable and liveable to cater for their increasing populations. Done right – and smartly – high-rises can be a solution to the challenges, according to experts.

Deo Prasad, Director of the Centre for Sustainable Built Environments at the University of New South Wales in Australia, notes that urban sprawl is “a far worse option than high-rises”, because a lot of transport problems and their associated health and economic impacts can be avoided.

This is especially true when building considerations extend beyond buildings as standalone elements to encompass additional factors such as roads and other infrastructure requirements as well as the energy impact of transport.

Minimise energy demand

However, high-rises as standalone buildings can also be made more sustainable and become part of the solution to the resource and climate crises. One way to achieve this is to use prefabricated components manufactured in a controlled, offsite environment – which not only cuts costs and improves health and safety for workers but also reduces noise and minimises the impact of...
construction on the local area by, e.g., lowering air pollution and CO2 emissions. The advantages of prefabrication become even more apparent with high-rises, as the labour and transport reductions realised are even larger than with low-rises.

Another way is to minimise energy demand by using smart solutions like double skin facades, which improve insulation and minimise solar gain while still maximising natural light – or by incorporating onsite energy generation into the building design, as Ramboll has done with wind turbines on one of the Middle East’s most iconic towers, the Bahrain World Trade Centre.

A GREEN VERTICAL VILLAGE ...

It is also possible to build a literally green high-rise – whose greenery benefits both environmental sustainability and human liveability. To cater for Singapore’s ageing population, Ramboll’s landscape architects partnered with WOHA Architects to design and build Kampung Admiralty (pictured). Singapore’s flagship “vertical village” – the first public development that integrates housing with public facilities for both young and old on a compact 2.2-acre site.

As several scientific studies have shown, having green areas close to home – or even just looking at plants – can offer psychological benefits, reduce stress and improve concentration.

“We developed a diverse and dynamic planting palette to serve as an inviting public environment for active living, including community gardens that exhibit local fruit tree species once in abundance at kampungs, or villages, giving the old familiar memories from their past and reminding the young of their history,” explains Tobias Baur, Project Director of Kampung Admiralty and Director at Ramboll Singapore.

The lush greenery forms a contiguous horizontal canopy, capable of lowering surface and air temperatures by providing shade and dissipating urban heat island effects, which in turn saves the energy used on air-conditioning, among other things, keeping the building and its users naturally cool.

... WITH BLUE INTEGRATION

Water is also an aesthetic, therapeutic and sustainable element at Kampung Admiralty. Much of the rainfall runoff from the upper stratum and the two tower roofs is collected, filtered and recycled. A lot of the runoff ends up in an eco-pond on level one, where a cleansing biotope recirculates and cleanses the eco-pond water.

This also helps to promote biodiversity and natural cooling effects – and as gravity helps the water to flow, the reduced need for pumping systems lowers energy consumption.

“The average annual rainfall in Singapore is 92 inches (2340mm). This means that over a million gallons of tap water can be conserved each year if the stormwater runoff is stored in the rainwater harvesting tank and reused for irrigation – approximately the average water consumption of 200 public housing, five-room flats in one month,” stresses Tobias Baur.
To optimise the design of offshore wind foundations and turbines, engineers need a platform for fast, robust and cloud-based data storage and execution. Ramboll has teamed up with Google to improve its in-house software in this area.
Universal Foundation and Ramboll have established close collaboration on a recent offshore wind project: the design and certification of the Mono Bucket concept shown in the picture including load iterations with MHI Vestas.

In March 2018 the Dutch government decided to develop the twin Hollandse Kust Zuid offshore wind farms - the world’s first to be built without a public subsidy. This represents a key development in the steep decline of renewable energy prices, and thus a major step in making wind energy increasingly competitive with fossil fuel.

However, there is still no guarantee that offshore wind will be preferred over fossil fuels, especially not in the developing world. Thus, the industry must continue to focus on cost-cutting measures, say energy experts like Luisina Berberian, Associate Director at Standard & Poor. In a blog at WindPower Engineering she writes that “technological developments have contributed most to cutting costs and the subsequent boom of offshore wind projects”. At the same time, she emphasises that “hurdles, like a complex design process” remain.

An innovative way to tackle some of these challenges and further cut costs can be found, for example, in Ramboll’s software program Ramboll Offshore Structural Analysis Package (ROSAP). The calculations that ROSAP performs are so accurate and advanced that the steel required for an offshore Chinese wind farm could be reduced by 20%, thus enabling Ramboll to beat a local competitor’s bid.

Ramboll will now further improve ROSAP by utilising measurement data from the offshore wind industry. To this end, the company will team up with Google Cloud and the IT specialists at Computas, a Norwegian IT solutions company able to deliver a better thought-out solution owing to its wide palette of competencies.

Zhang Yi
Project Manager, Chinese State, Power Investment Cooperation
to provide the necessary advanced technologies that are both scalable and extendable. Google Cloud will supply the required advanced analytics packages, also both scalable and extendable, and Ramboll is enrolled in the Google Partner Program and participating in Google’s training courses on cloud architecture and data analytics – the aim being to establish a robust and fast cloud-based data storage and ROSAP execution platform.

First foreign advisor in China
ROSAP was originally developed by Ramboll’s oil and gas division back in the 1980s. Around 2000, Ramboll added a small version for offshore wind turbines, which has now grown big enough to enable bids that are more competitive than those of state-supported Chinese companies.

Ramboll has a market share of around 60% of offshore wind foundations installed worldwide – all of which have a bearing capacity capable of supporting turbines even in weak and earthquake-prone seabed soils.

In 2015 the company became the first foreign advisor to design one of China’s largest offshore parks – SPIC Binhai North H1 in Jiangsu province, five hours’ north of Shanghai – and since then three other design orders have come from China, as well as two orders for design from Taiwan and one for project development in Japan.

“The secret here is that ROSAP can optimise the design of the wind turbine foundations,” says Søren Juel Petersen, Wind Market Director at Ramboll.

No over-sized buffer
Competitors in Asia and elsewhere typically purchase software externally to calculate the impact of all relevant factors on wind turbine performance and stability. With ROSAP, Ramboll has all the answers in-house: How do waves, currents and tides impact the foundations – both in the general short term and in relation to long-term corrosion protection? What about the weight of – and loads from the wind turbine
itself? And what kind of seabed are we talking about here? How does it react, for example, to soil liquefaction – a phenomenon where soil loses significant strength and stiffness in response to an earthquake or other applied stress, thus causing it to behave like a liquid?

Ramboll typically calculates about 5,000 different combinations of loads from the above factors – referred to as load cases per wind turbine position.

“When there are, for example, 100 turbines in a farm, 500,000 transcripts are required. On this basis, we can with great certainty determine how strong the various elements of the wind turbine foundation should be, among other things. And with the new cloud-based ROSAP execution platform, the large number of load calculations and associated data processing can be easily handled,” says Søren Juel Petersen.

He stresses that without a software program like ROSAP calculations will often be over-conservative.

“You have to put in a buffer, and as you have to be cautious, you typically put in too large a buffer, thus investing too much. We can avoid this because our calculations are so accurate,” he explains.

Zhang Yi, a project manager with the Chinese State Power Investment Cooperation, confirms that the total price was a decisive factor in awarding the SPIC Binhai North H2 contract:

“Ramboll could supply a solution that was 20% cheaper than what the competitors had to offer.”

We are very pleased that Ramboll has chosen Google Cloud Platform to help leverage data to improve offshore wind efficiency.

Mads Kjærsgaard
Sales Manager,
Google Cloud Denmark

OPTIMISING WITH DIGITAL WAVES

There are other smart ways of improving offshore wind projects. Ramboll has constructed a digital wave tank that uses computational fluid dynamics (CFD) to help design wind turbine foundations and substations that are faster and cheaper to construct and more cost-efficient to operate, because they are based on real-world data, simulations and assessments.

Ramboll has worked with CFD for over 20 years, initially on projects for building interiors where the technology helped to dimension ventilation systems and improve fire safety. This gradually extended to other areas like urban planning in Hong Kong, baseball stadiums in the USA and advanced railway and high-speed train projects in the Nordics.

The digital wave tank and other CFD performance simulation models were used to optimise 44 offshore wind turbine monopiles for the Northern Offshore Wind farm in Belgium. This generated more than one million euro in construction savings – because the solution used less steel and avoided on-the-job redesign – plus life-cycle maintenance costs went down 75%.
The lifespan of wind turbines can be extended cost-efficiently – especially on offshore farms, where turbine lifespan can potentially surpass the usual 20-25 years.

By Michael Rothenborg

Offshore wind farms have to be much more robust than onshore ones, especially because wind, waves and salt corrosion have such a heavy impact. Conditions like these put stress on the constructions and cause fatigue – and the structural materials eventually wear out.

Consequently, the world’s first offshore wind farm, Vindeby, built near Lolland in Denmark in 1991, has just retired its turbines. And all around the world similar decommissioning projects are approaching, as offshore wind turbines typically have a service life of just 20-25 years. But it does not have to be this way, emphasises Lisa Ziegler from Ramboll (pictured).

She has won three prestigious international awards for her PhD study “Assessment of monopiles for lifetime extension of offshore wind turbines”, including Best Paper at the International Conference on Ocean, Offshore and Arctic Engineering 2017. She will be submitting her PhD to the Norwegian University of Science and Technology later in 2018.

A minimum number of sensors
Around 2010 the industry started installing larger wind farms with turbines from the multi-MW class - these are the turbines whose lifetime could be cost-effectively extended.

Further optimising designs
It is becoming increasingly evident that measurements are a key element in lowering not only capital expenditures but also operating expenses. Offshore wind turbines and foundations will be strategically monitored in the future, and having full control of different sources of real-time data is vital, emphasises Ronnie Pedersen, project manager of the development project with Google.

Ramboll is expanding the smart service by providing a cloud-based data storage and execution platform that systematically run data to facilitate decisions on, e.g., life-time extensions or inspections.

“This can be used to offer new real-time insights into the health of the structure and further optimise future structural designs, for instance, by further minimising the undesired conservatism in the calculations, which stems from the complex

and could deliver a better thought-out solution owing to its wide palette of competencies,” says Zhang Yi.

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interaction between wind turbine and turbine foundation,” says Ronnie Pedersen.

The system used for the long-term storage of the measurement data must have two properties. It must first be able to scale to the large volumes of data produced and also allow fast queries to be performed on the stored data. This is achieved with Google Cloud Platform. Google’s systems offer the added advantage that the data storage has built-in support for secure, transparent user access control. This can be useful in allowing partners and certifiers direct access to subparts of the data.

“Google is committed to carbon neutrality in our own operations, and we are very pleased that Ramboll has chosen Google Cloud Platform to help leverage data to improve offshore wind efficiency,” says Mads Kjærsgaard, Sales Manager for Google Cloud Denmark and Iceland. “We look forward to being a part of Ramboll’s efforts to improve adoption of green energy.”

A crucial part of her PhD is to analyse methods that can be used in lifetime extension assessments and to investigate how they can decrease the risk involved in making lifetime extension decisions. Her work resulted in a novel concept for monitoring fatigue loads on the support structures of offshore wind turbines – a monitoring system that only requires a minimum number of sensors.

**Dismantling onshore wind turbines**

The lifespan of onshore wind farms can be made more sustainable too. The German Federal Environment Agency (Umweltbundesamt) has launched a 19-month project to develop a circular economy approach for dismantling end-of-life onshore wind turbines.

The agency has commissioned Ramboll to gather and assess data for creating policy approaches concerning the management and reuse of waste materials generated during the end-of-life dismantling process as well as to provide feedback to manufacturers. The team will, for instance, conduct a survey to establish the current status of onshore wind turbines and the practices used to dismantle them, and will evaluate the associated waste streams (which contain carbon fibre components, gearboxes, lubricants and permanent magnets, etc.). This will help inform the future design of more suitable wind turbine components.
The world's water infrastructure is aging. Experts and organisations like the EU Commission and the European Federation of National Associations of Water Services have pointed to the need for more maintenance and renewal. Unless these issues are resolved, water systems will be less efficient and more prone to damage – and thus more expensive and resource-wasting in the long run.

A lot of the equipment used in water and wastewater treatment plants has become outdated, so water supply companies are looking for efficient and affordable ways to upgrade. Ramboll water experts in Norway and Denmark are currently helping to develop a promising new technology that uses 3D scanning done with a phone to make refurbishment models for water plants.

Using a mobile phone for 3D scanning can help refurbish wastewater treatment plants cheaply and efficiently – and this type of digitalisation can also be expanded into other areas.

By Michael Rothenborg and Martin Zoffmann
“Until the late 1990s, water plants were usually designed on paper and in 2D,” explains Michael Nielsen, Head of Department at Ramboll. “We find that many clients only have a few old pen drawings stashed away somewhere, and they’re typically incomplete. Such clients therefore need a new digitalised model of their plants. With our new technology we can do this much more cheaply and efficiently with a phone than with a big, traditional 3D scanner – and in so doing perhaps gain an opportunity to help clients with larger projects too. For instance, a total redesign of entire wastewater plants.”

Less money, more details
The app is based on technology developed by Google and supports both virtual reality (VR) and augmented reality (AR).

Basically, you invest around EUR 600-700 in a 3D-enabled phone, and then install the Imerso scanning app, which integrates mobile scans into CAD drawings. When you do a scan, your data is saved online in the Imerso web platform, where you can view your data, share it with others, take notes and measurements and export your scans to work offline in any industry software.

You then walk inside the water plant, use the camera, “connect the dots” on your computer – and you now have a 3D model including point clouds and mesh files that are dimensionally stable to within 2 cm.

“It takes around half an hour and costs less than EUR 1,000, where a traditional 3D scanner on a tripod typically takes half a day and costs at least EUR 6,000. And the phone scan is more detailed than one from a scanner on a tripod – it is small enough to register the backs of water pipes,” Michael Nielsen points out.

The 3D model enables processing equipment in existing facilities to be rehabilitated and replaced much more efficiently. For instance, equipment from a pump supplier’s website can be “copied and pasted” into your virtual plant. This makes it far easier to generate different refurbishment scenarios.

Vast potential
The app was initially only used in water infrastructure projects as a replacement for the old camera, measuring stick and registration method. But the app also allows quick scans of manholes and construction sites, and the scans are instantly available for inspection and measurement in a regular browser.

“This technology is of great use in other services like buildings, surveying and HVAC (heating, ventilation and air conditioning),” says Jakob Myking, Head of IT- and Digitalisation at Ramboll Water Norway.

He emphasises that the technology can be used throughout the value chain, including for facility management, status documentation, building information modelling (BIM) control and planning and design:

“You instantly get a digital twin of the object or site of interest, and only your imagination sets the limits for what the data can later be used for.”

Saving time for clients
One of many projects where Ramboll has used the app successfully entailed establishing two mud strainers at the Høvringen wastewater treatment plant in Norway. For the project 25-30 hours were spent generating 3D scans and modelling that determined the space required and the challenges posed by irregular walls and ceilings as well as by a wide range of existing pipes and electricity.

Another example is a mini-treatment plant that was to be established in an old, discharge tunnel at Killingdal in Trondheim. Ten to 12 hours were spent generating the 3D scans and modelling used to find out what could be fitted into the tunnel – a process that the narrow and irregular tunnel walls made extremely difficult to execute with traditional measurement methods.

Statsbygg (The Norwegian Directorate of Public Construction and Property) is among Ramboll’s clients in this area.

“The app is saving us a lot of trips to the construction site, but it is also saving us time, money and not least environmental impact,” says Erik Antonsen, Project Director at Statsbygg.

The app is saving us time, money and not least environmental impact.

Erik Antonsen
Project Director, Statsbygg
ON THE PATH TO CLIMATE CLARITY
New software could provide city leaders and policy-makers with the tools to finance more climate actions. The first step is a report from Ramboll and C40.

By Martin Christiansen

What if city officials could go online, browse through the interconnected pathways and see how one climate action might have positive spillover effects in other parts of the city, and – equally importantly – click to learn how other cities have tackled similar challenges?

This was the ambition that led C40 Cities and Ramboll to develop a new pathway framework for describing and measuring the wider impacts of urban climate action.

The demanding offline inventory has already been taken and made available in report format. Now, all of this data is to be digitised to produce an online tool that helps cities make the case for climate action. A prototype tool is currently in the pipeline.

Reaching the Paris Agreement
According to Tom Bailey, Head of Research at C40, the absence of such a tool has made it hard for cities to establish a convincing business case for funding climate actions:

“Various methods already exist on the topic, but we know from previous research and workshops with city officials that our member cities lack a comprehensive and robust evidence base to drive their climate actions. And, so far, the evidence has not been in the form needed by leaders and policy-makers. We aim to change this with our report and online tool, as this is vital to reaching the world’s climate goals, e.g., in the Paris Agreement,” Tom Bailey says.

The lack of evidence and support available to cities on how climate change relates to health and prosperity must be addressed. This
complexity makes taking decisive action very challenging when it comes to understanding the interconnections between urban agendas, and then to comparing and prioritising them, says Jesper Nygård, Managing Director of the Realdania foundation: “It’s key to have a thorough mapping of how an action in one area affects other areas – positively or negatively. Mostly positive, I would say. Providing solid data is almost a meta theme; we have to move from thinking to knowing. Or as Michael Bloomberg puts it: In God we trust, everyone else bring data.”

Gaining support for action
This instinctual prioritisation of other agendas over climate can mean city stakeholders are not open to considering or supporting climate action, and can pose a major challenge in cities in the developing world, where other urban challenges are particularly prevalent. This tendency exists despite the reality that the human and economic costs of more frequent and severe weather like hurricanes and other consequences of global warming can be tremendous. According to Karin Attström, one of Ramboll’s experts on Social &

Investments in climate projects must be made through integrated masterplanning and cross-sector perspectives.

By Michael Rothenborg and Martin Zoffmann

A key point of the new C40 report and other studies is that any investment in making our cities resilient to climate change must create added value.
This could be achieved, for example, by delivering a solution that lowers both greenhouse gas emissions and air pollution or that makes the local environment of a climate resilience project more attractive for citizens. Investments in city infrastructure can become value drivers rather than cost drivers if the world’s cities take a holistic approach and base investment decisions on thorough analyses of the environmental, social and economic impacts of such projects.

An earlier C40 report – ‘The Co-Benefits of Sustainable City Projects’ – mentions several good examples. For instance, in Istanbul, Turkey, the documented benefits of bus rapid transit (BRT) include reduced transit travel times, reduced transit operating costs, travel cost savings, CO2 emissions reduction, road safety effects, improvements in air pollutant exposure and physical activity benefits for citizens.

Two cases with LED street lights from Los Angeles and Sydney also point to numerous benefits.

Community engagement
Ramboll works with these types of added benefits and integrated solutions. In New York a climate adaptation project (pictured) is helping the city address the higher frequency of heavy rainfalls by integrating traditional underground drainage infrastructure with above-ground, nature-based solutions and including them in the ongoing urban planning. This will also foster new ways of engaging the community. The cost-benefit analysis for this project also includes rising property prices, new recreational areas and other, often overlooked but important, socio-economic factors.

In Washington, DC, Ramboll has used advanced hydraulic modelling to illustrate how a rising sea level and the current level of climate resilience planned for storm surges would only reduce future
significant these impacts are likely to be for a given city, that city cannot make a firm case for, or might even encounter opposition to the action,” Attström explains.

A full systems approach
The expert group behind the report and online prototype encourage stakeholders to approach urban climate action from a systemic perspective. Urban life is highly interconnected, as the environment, society and the economy all impact each other in a series of complex dynamics.

People’s health and prosperity are intimately dependent on environmental management and biodiversity. The safety and fairness of jobs enhance physical and mental health. A city’s aesthetic quality and cultural heritage drive tourism, migration and, therefore, economic prosperity. Improved equality is directly related to trust, civic participation, social cohesion and sustainability.

This intuitively makes sense, yet is very hard to practise, according to Karina Solsø, an organisational psychologist with a PhD in Complexity Management from the University of Hertfordshire, London: “Most of the people who rise through the management hierarchies learn that in order to be trusted with responsibility, they need to meet their targets on time. This often leads to a form of thinking and practice that focuses on targets that can be reached without dependency on more stakeholders than absolutely necessary. Managers need to take the fact seriously that without consistent reflection on the game that everyone is caught up in, they run a great risk of consistently facing suboptimisation. Training and tools that reveal how one thing is connected to another will surely provide one solution to a complex dilemma,” she says.

Without consistent reflection, you run the risk of facing suboptimisation.

Karina Solsø
Organisational Psychologist

flooding from the Potomac River to a limited extent. The cost-benefit analysis of the higher protection level recommended includes added value in the form of an extension of the existing Riverwalk Trail, additional green space, a living shoreline concept and better access – all of which also benefit citizens’ health.

Added value is also a key word in a strategic action plan for integrated cloudburst management that Ramboll is developing for the City of Gothenburg in Sweden. Gothenburg faces huge risks of flooding due to storm surges from the Göta River, potentially combined with heavy rainfall. As such, Gothenburg is the first Swedish city to use structural plans for managing cloudbursts within catchment areas. The ambition is to develop multi-functional solutions that create added value in terms of ecosystem services – i.e. increased benefits from the natural environment – and more recreational urban space. ■
One of the largest construction projects in Denmark has experienced less than half the usual number of accidents, largely due to an interactive game that workers are required to play before starting at the site. The game is now being distributed to other countries.

By Michael Rothenborg

Life is no Nintendo game. So goes a... not-so-old saying proclaiming that there is no second chance at life. No chance to be resurrected and live on like in a Nintendo game.

But, luckily, sometimes you do get another chance - a chance to practise a difficult skill in a game before having to do it in real life. This has long been possible in selected contexts like pilot training with flight simulators, but now it can also be done in the health and safety area.

Ramboll has developed a new, interactive 3D game - a virtual reality (VR) simulator of sorts - that can help construction workers anticipate and avoid accidents on-site.

The working environment is becoming increasingly important, due in part to its inclusion in the UN's Sustainable Development Goals (SDGs). For example, goal number 8.8 states: “Protect labour rights and promote safe and secure working environments of all workers”.

Accidents more than halved
The working environment has been a top-priority focus during the construction of the so-called Super Hospital in Gødstrup, Denmark – one of the country’s biggest construction projects. As Project Manager Michael Hyllegaard from DNV-Gødstrup puts it:

“As a hospital, we focus on not generating customers for our own business. From the outset our ambition has been to have zero serious accidents on-site. Therefore, we tried an alternative to the traditional safety training.”

In this case, the “alternative” was Ramboll’s 3D game - the first time VR has been used this way in Denmark. To gain access to the site, employees had to perform a range of safety tasks and procedures in the game.

And it worked. In the first five years of the construction process - from 2012-2017 - only 12 workplace accidents occurred. The most serious was a broken foot.

This is less than half the average for Danish constructions sites of this kind, and the success...
rate has been similar on other Danish construction projects where the 3D game has been used.

**See it before it happens**

Special consultant and game developer at Ramboll Åge Staghøj explains that the 3D game guides employees through a number of safety exercises on the virtual site.

“It engages the workers and teaches them to act and take responsibility for their own safety, and so improves their ability to see an accident coming at the construction site,” Åge Staghøj says.

There have been monthly competitions among craftsmen to come up with the best ideas for making the working environment even safer. A team from Icopol, for example, thought of a tripod that prevents gas bottles weighing 60 kilograms from toppling over. The tripod and more than 1,700 other ideas for improving health and safety at work testify to the proactive approach that the craftsmen have taken, Åge Staghøj points out:

“And, interestingly, both the craftsmen and site managers say that having good working
It will be easier for us to identify where we need to make improvements.

Synnøve Lyssand Sandberg
Director, Statsbygg
Modern hospitals operate 24 hours a day, 365 days a year. Behind the scenes, logistics play a vital role in keeping things running smoothly and efficiently, and this process is increasingly becoming automated.

This is in response to changes in lifestyles and demographics which are putting pressure on healthcare facilities as never before. "Improving the quality of – and access to – healthcare, while controlling costs as populations age and grow is a major challenge for the healthcare sector," says Michael Gustavsson, Global Division Director of Hospitals at Ramboll. "Automation of internal hospital logistics is a way for hospitals to reduce costs, secure documentation and spend less time on non-care related tasks."

He points out that hospitals should be seen as an eco-system where food is brought in and waste thrown out, while beds, medical instruments and thousands of other things are constantly moved around. The more this is automated, the more time healthcare staff can spend with patients.

Freeing up resources

Ramboll has recently acquired German company MMG, which has long specialised in implementing healthcare logistics, in particular automated guided vehicles (AGVs).

AGV technology can be tailored to work in existing healthcare facilities but is particularly useful if factored in during the initial design of new hospitals as the technology has an impact on the overall design and blueprint of the building.

Denmark is investing significantly in new hospitals and in Aalborg, where Ramboll has been involved in building the new University Hospital, the automation of logistics has been an integral part of the design process.

"It is expected that new hospitals should offer better and more effective treatment at lower costs than older buildings," says Heine Overby, Head of Department at the New Aalborg University Hospital.

"AGVs are among the technologies that can help make our processes more effective. They can transport goods such as linen, food, medicine and empty beds and deliver them to each department as they need them," he says.

EASY WORK – AGV FACTS

Automatic guided vehicles travel along the floor of facility on designated paths. They are directed by a combination of software and sensor-based guidance systems. They travel along a predictable path with precise acceleration and deceleration and are able to detect any obstacles, making them perfect for the safe movement of loads.

The AGVs navigate using guidance technologies such as magnetic tape or bars mounted on the floor, lasers, and optical sensors. This makes it easy to alter the routes they travel and expand the AGV system in response to facility changes or demand.

By Andrew Somerville and Michael Rothenborg
A new tool makes it much simpler to co-create virtual architecture and explore progress models of a building design.

By Helle Pryds Bruun and Michael Rothenborg

You can see, show and discuss planned buildings using a new digital methodology where Ramboll takes co-creation to the maximum by giving the visualisation tool to clients themselves.

This is done by exporting the database design model at intervals to a standalone .exe file that renders the building information modelling (BIM) status of a building project, including all of its textures and landscape elements (trees, grass, etc.) as well as accurate sunlight simulations.

“The beauty of using an .exe file is that it is a standard file type – this means clients don’t have to install any software on their computers in order to run the simulation,” explains Shane O’Brien, Senior Architect at Ramboll. It is a completely self-contained presentation that is also platform
The .exe files are uploaded to the project cloud, where clients can download and explore them at their leisure, either on a standard PC or with a VR setup. Crucially, clients have no learning curve for navigating the model.

“It’s as simple as a basic video game,” says Shane O’Brien. He adds that the idea is to use the ‘fail fast’ principle.

“The project understanding that clients are afforded by navigating through the preliminary stage of a project and, for example, examining apartment layouts or running quick sunlight-simulations themselves allows for deeper client engagement and collaboration in the design process.”

A realistic sense of the project
The method has been used on the ‘Slaktaren’ project in Eslöv Municipality, Sweden (pictured), where the clients have been able to explore fully lit and textured navigable progress models of the design.

Sten Carling, Head of Real Estate Development at Eslöv, was introduced to the Enscape model to explore a planned block consisting of approximately 90 apartments.

“By using the model myself, I’ve been able to show the design of the planned buildings and discuss them with various stakeholders such as property managers, board members, city officials and others,” says Sten Carling.

“Exploring a 3D model makes it easy to get a realistic feeling for how the building design will look and fit into an urban area, and to identify issues that need further examination. The possibility to easily make sunlight studies has impressed us. The program is very easy to manage yourself, and it gives a realistic sense of the project. It almost hurts to run into a wall or fall off a balcony.”

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Sten Carling,
Head of Real Estate Development,
Eslöv Municipality

"The program is very easy to manage yourself, and it gives a realistic sense of the project. It almost hurts to run into a wall or fall off a balcony."
The inception of Highways England’s Smart Motorway Programme (SMP) is proof that innovation can play a central role when it comes to mobility. The product design process required a change when the need arose to provide the highways with an even greater number of physical elements, such as signs and signals, supported by steel gantry structures, and to do so under even tighter deadlines.

The use of the bespoke software “Mango”, written in-house, has enabled Ramboll to automate, manage and evolve the design of the lightweight structures for the SMP. The automated gantry product, combined with a process-based design and modelling platform called ‘Smoothie’, a custom data management system called ‘Sorbet’ and a bespoke and flexible design solution named ‘Soufflé’, all come together into a living system developed by Ramboll. The system incorporates analysis software, 3D visualisation tools and 40 years of experience to provide efficient and effective design products for the highways industry.

Thanks to Ramboll’s innovation in the use of process-based product design systems, gantry design costs on a scheme-by-scheme basis for the SMP are anticipated to fall by almost 60% over the life of the current programme. Saving many thousands of euros in design and construction costs every year, the programme is constantly evolving through ongoing dialogue to address current and emerging client requirements. The system is currently used to provide approximately 95% of all of the highway gantry designs in the UK and accounted for the design of over 300 gantries in 2016 alone.

Adoption in other designs
We have taken the principles, knowledge and lessons learnt on this project to widen the application by adopting it in the design of other civil engineering structure types, including culverts and steel/concrete composite bridges.

In tandem we have developed an approach for property professionals in the residential market that are looking for ways to increase cost certainty and return on investment. This so-called Dynamic Masterplanning is a way of radically enhancing the appraisal of new developments by incorporating engineering and fabrication criteria for buildings at the early decision-making stages, a method enabled by developing an automated process of form generation and evaluation.

Aiding in the work of architects, landowners, developers or whole city regions, the Dynamic Masterplanning tool can be used to model, manipulate and explore development sites, thus helping achieve optimal developments by exploring a wider solution space than possible with traditional methods. The tool rapidly generates and evaluates multiple options against site-specific constraints and client aspirations. This makes it possible to analyse more designs in less time and bring this evaluation data to the forefront of the design process.

Great savings on gantries for Highways England are mirrored in project optimisation for Transport for London, among others.

By Tom Channell, Ruth Johnson and Mark Pniewski
process and thus inform critical, early decision-making.

We have used this approach for clients like Transport for London, where on one site the approach resulted in 5,000 m² more residential space than the client previously thought feasible. Ramboll has also optimised solutions for private clients, and not just in the buildings market. For example, the company developed an interactive tool to explore design solutions for a bridge between two manufacturing buildings for a major manufacturing client, which entailed a collaboration between our buildings and bridges team with a digital platform designed specifically for our client’s needs.

"Client Quotes"

"The significance of the gantries design systems has been central in the development of the Smart Motorway concept, thus providing a standard of excellence to the wider motorway environment."

Paul Unwin
Lead Sponsor M4 and M25 Smart Motorways Programme
Major Projects
Highways England

"Ramboll has provided innovative advice when looking at options for building over a railway cutting. Their Dynamic Masterplanning platform really helped visualise and assess development potential by showing levels of scheme massing possible from changes in foundation design and construction methods. The technology involved meant that the advice was very responsive to changing variables as the project progressed."

Martin Teodorczyk
Senior Property Development Manager
Transport for London
How can you pay tribute to history and sustainability by turning an old grey wastewater treatment plant into a green ruin park?

By Michael Rothenborg - Photo: Niels Hougaard

Birds are singing, and the leaves are colourful, but another assault on the senses - the smell of wastewater - drowns the idyll. Ålebækken is a grey spot in one of Greater Copenhagen’s greenest areas. Close to a branch of the National Museum of Denmark and Dyrehaven, a UNESCO World Heritage Site, lie the remains of an old wastewater treatment plant that is closed to the public.

Now, the Lyngby-Taarbæk Utility Company has financed a project to clean up and open the 30,500 m2 area. This is possible because the project is combined with establishing a new underground reservoir for wastewater that will reduce the impact on Mølleåen creek.

“We’re looking forward to opening up the area with help from Ramboll and Sweco – to benefit citizens,” says Nina Caspersen, Project Manager at the Lyngby-Taarbæk Utility Company.

Originally, a traditional clean-up was planned, with all the old concrete slabs and other industrial elements to be removed or demolished.

“But then we asked ourselves, ‘Why not preserve and reuse the old industrial structures and create a new and sustainable landscape?’” says Camilla Julie Hvid, Landscape Architect at Ramboll. “When you transform the existing structures, you create a whole new type of post-industrial landscape – a sort of green ruin park – where you communicate the narrative otherwise hidden here.”
Recycle soil, trees and plants

The old, trickling filter will, for instance, be turned into a new form of garden that emphasises the industrial structures and geometry.

The plan is to recycle as much as possible from the existing area. The most contaminated soil will, of course, be disposed of, but the lightly polluted earth as well as the clean surplus soil from excavations will be re-used on site. The wood from felled trees will be used as material for park paths and fixtures, and young trees and plants will be dug up and collected for reproductive purposes. Or some might be left in place – for instance, the green moss covering the old, grey water canal, which enhances the jungle-like feel of the abandoned industrial site.

The project is partly inspired by Landschaftspark Duisburg-Nord in Germany, where an old coal-mining and steel production area has been transformed into a recreational area. And there is a general trend towards upgrading or broadening the sustainability aspect when sites like these are renovated, recreated or regreened.

But this is one of the first places in the world where the structures of an old wastewater plant could be used as a framework for such a recreational area.

“And there are a lot of old sites like these all over the world – especially in Northern Europe – where you could do the same,” says Camilla Julie Hvid (pictured below).
**HOW TO KEEP COMMUTERS ON TRACK**

When a crucial, new tunnel in Copenhagen was under construction, the challenge was to make the temporary railway bridges above it strong enough – while also providing sufficient space for construction work in the tunnel below.

By Michael Rothenborg

Danish rail commuters in Greater Copenhagen had to live with taking provisional buses instead of trains for some three months while the Nordhavnsvæj Tunnel was being built. But it could have taken much longer – as much as a year, if Ramboll’s engineers and their partners had not applied their technical ingenuity and creativity to constructing the tunnel under the tracks.

“It was a tough challenge, because there were so many aspects to consider,” said Steen Nielsen, Ramboll’s Project Manager for Nordhavnsvæj.

Nordhavnsvæj opened in late 2017 and is the City of Copenhagen’s largest infrastructure project in decades – a tunnel leading traffic from the Helsingør motorway to the harbour to relieve congestion in the city centre.

If done traditionally, the tunnel construction would have required that the entire stretch of railway be closed for up to 12 months.

“But this wasn’t feasible – so we had to figure out how to make temporary railway bridges function as effectively, inexpensively and quickly as possible,” explains Steen Nielsen.

Unconventional support structure

To complete the plan, Ramboll’s engineers joined forces with the City of Copenhagen, which is the project developer, and the contracting company Züblin on everything from access to the construction pit to alternatives for how the tunnel should cross under the Strandvejen road. This led to the decision to create a temporary railway bridge with a new kind of support structure.

Traditionally, secant piles are constructed of intersecting concrete piles drilled into the ground. But here the geometry was more complex. The tricky part was that once the temporary bridge had been erected on top of the piles, and trains could run across it, the construction workers needed to be able to dig the tunnel underneath. This meant there had to be enough space between the piles to allow the huge machines to drive through. But the piles also had to be sufficiently close together to meet the strict requirements for railway stability and rigidity.

“We did complex calculations with 3D models to prove that the tunnel could be constructed and completed – despite all the piles that were in place during the work,” says Steen Nielsen.
IT IS TRULY SMART
(IF IT IS SUSTAINABLE)

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