

**WITHOUT
LIMITS**

THE FUTURE OF INFRASTRUCTURE

**CREATING OPPORTUNITY
FOR EVERYONE**

THE FUTURE IS NOW

infrastructure's role
in economic recovery

BUILDING A BETTER CASE FOR INFRASTRUCTURE INVESTMENT

Infrastructure has an important role to play
in getting the economy moving again

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DRIVING
INNOVATION
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EXECUTIVE SUMMARY

Our third Future of Infrastructure report comes at a pivotal moment. Countries around the world are wrestling with an unprecedented global shock that knows no boundaries: coronavirus. We will recover, but nobody knows how long that will take. The only certainty is that there will be change.

As practitioners we must constantly analyze the future so that the infrastructure we build stands the test of time. A crisis of this magnitude will lead to deep shifts, some of them unexpected. Priorities will change, some of them for good. Our systems and structures will need to adapt. Resilience and innovation will be more important than ever.

As restrictions start to ease, attention will be focused on what needs to be done to ensure a safe return to work, education and eventually leisure activities. How should we travel? Where should we work? How should the spaces where we work and learn be organized?

Once coronavirus has been tamed, there will be new demands. Our health systems will have different wants and needs. Technological solutions that have helped us fight the virus and ease its economic consequences will lead to permanent changes, some of which are only just beginning.

On the policy side, attention is rightly focused on the immediate priorities of the health crisis and the related economic crash, but we should be wary of letting other considerations slide. If we are to emerge from this pandemic fit to tackle the other crisis — the climate emergency — we need to keep a lid on emissions. We must also continue to value the social impact of our infrastructure decisions, particularly if we are to help the most vulnerable in our societies — those who have been most impacted by coronavirus.

These considerations are addressed in our report.

History tells us that investment in infrastructure has an important role to play in helping economies get back on their feet. In the short term, it provides much-needed jobs, while strengthening the backbone of the economy for the long-term. With the right choices, infrastructure can help society emerge stronger from this crisis. At AECOM, we feel we have a duty to do everything in our power to ensure that it does.



THE FUTURE IS NOW

INFRASTRUCTURE'S ROLE IN ECONOMIC RECOVERY

For the infrastructure industry, AECOM CEO **Michael S. Burke** says that means asking questions such as: can we approach what we build better? How can we make populations more resilient to global shocks ahead?

As the coronavirus outbreak deepens and inflicts a tragic toll, economies around the world are being flattened with unprecedented force and speed. Governments are advancing emergency aid and stimulus packages to respond to the immediate health crisis and prevent economies from stuttering to a halt.

The global community has been badly shaken, but already, there is a determination to emerge from this stronger: to rethink how we do things and reboot. For the infrastructure industry that means asking questions such as: *can we approach what we build better? How can we make populations more resilient to global shocks ahead?*

\$2.2T

The \$2.2 trillion coronavirus package is the largest federal relief effort in U.S. history.

Of course, the scale of what's required is immense. The U.S. administration has responded with a \$2.2 trillion package, the largest federal relief effort in U.S. history.¹ Underscoring the magnitude of the challenge a further stimulus package — possibly even larger — is already in the works,² including major infrastructure investment plans.³

In Asia, where the outbreak began, record stimulus packages have been announced in Japan,⁴ Singapore and South Korea, while Australia's efforts to date amount to one tenth of its economy⁵. China has signaled a bigger stimulus could be on the way.⁶ Meanwhile, European Union leaders are working on a collective response.⁷ Italy,⁸ France⁹ and

Germany¹⁰ have laid out their own relief efforts ranging from €25–50 billion, and Spain is planning the biggest financial mobilization in its democratic history.¹¹ The UK has already promised to pump more into its economy than during the decade-old financial crisis.¹²

Despite these Herculean efforts, financial markets remain skittish, fearful of how much this will cost. It is impossible to predict the full economic impact of the coronavirus because we still don't know how long we will have to fight it, and how much resources the effort will consume. The IMF expects the GDP growth for 2020 to be negative, with "a recession at least as bad as during the global financial crisis or worse."¹³ ➔

It is likely that additional stimulus packages will be required, beyond those already announced. Underneath the headline figures will come important choices about how to spend that money. Those decisions will impact the speed and depth of recovery, influence the longer-term health of our economies, and begin to define what our new normal is likely to be once the coronavirus is abated — hopefully for good.

A time-honored way of providing an immediate lift to economies is to fund infrastructure. The injection of income leads to more spending, which creates more income and so on — the so-called ‘multiplier’ effect. A study for Business Roundtable, an association of chief executive officers of America’s leading companies, found modernizing our highways, bridges, airports, and waterways will produce big returns. Every \$1 invested in infrastructure returns roughly \$3.70 in additional economic growth over 20 years, the modeling study by University of Maryland showed¹⁴. That’s nearly a 4:1 ratio of return on investment. During a recession, infrastructure investment is often deficit financed meaning it can have an even greater effect.

At the same time, spending on infrastructure boosts economic prospects in the medium and long-term through much-needed improvements to facilities and connectivity. In the U.S. current infrastructure spending

at federal, state and local level is at an all-time low and is already insufficient to meet both maintenance and expansion needs. The \$4.6 trillion backlog of deferred projects is estimated to be limiting economic growth by \$3.9 trillion over the next five years.

After the 2008 financial crisis, the U.S. economy bounced back faster than Europe, in part because its financial stimulus was larger¹⁵ — with 14 per cent of funds earmarked for infrastructure. However, despite its relative success, the American Recovery and Reinvestment Act (ARRA) had its weaknesses, the most cited being its failure to limit unemployment. With the unemployment rate forecast to skyrocket to 32 per cent in the U.S. alone, policy makers should consider increasing spending on infrastructure projects, particularly those that will add the most jobs. On average, \$100 billion of infrastructure investment adds one million jobs¹⁶ — more if the projects are transport-related because of the knock-on effects of a more efficient economy¹⁷.

Another criticism of ARRA was that the infrastructure it funded was supposed to be “shovel ready.” The New York Times in 2010, noted that it wasn’t possible to get started immediately due to the pipeline process of approvals, the design to ensure environmental requirements, and the need to ensure that fair contracting practices took place. Most took at least six months to get off the ground. ➔

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SPENDING ON INFRASTRUCTURE BOOSTS ECONOMIC PROSPECTS IN THE MEDIUM AND LONG-TERM THROUGH MUCH-NEEDED IMPROVEMENTS TO FACILITIES AND CONNECTIVITY.



Los Angeles Metro, U.S.

Policy makers have an opportunity to learn from ARRA. To ensure the money is well spent, we have three recommendations:

1/ ACT NOW:

to avoid delays in awarding construction projects, agencies should start preparing now. Much of the planning work, from accelerating permitting to tender documentation, can be done virtually.

2/ REMOVE HURDLES:

administrations should begin fast track planning and environmental approvals now and engage the industry to help clients prepare projects for procurement.

3/ FLEXIBLE PROCUREMENT:

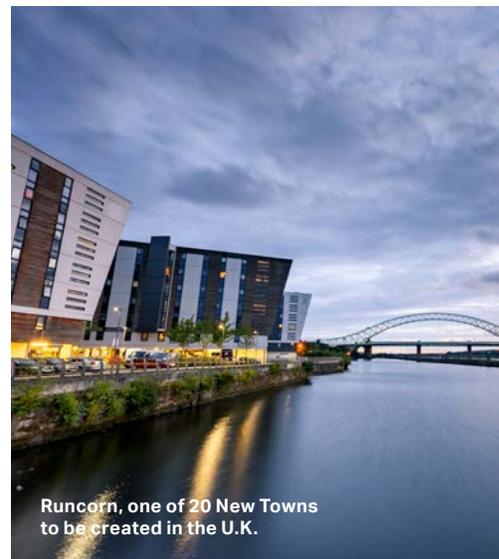
projects can be delivered faster thanks to design-build, which allows projects to start sooner, and digital delivery, which improves efficiency. These methods should be embraced, as should the encouragement of unsolicited proposals and the engagement of the private sector in financing of projects.

When stimulus funding becomes available, it will be most impactful if spending bodies have a comprehensive infrastructure stimulus program to guide priorities — a program that channels the same ingenuity driving today's healthcare response into

new thinking to address our nation's disrepair and build infrastructure for the future.

While immediate payouts are needed to keep households and businesses afloat, infrastructure spending provides one of the greatest returns on investments. Incorporating a full asset lifecycle approach that balances shovel ready projects with more strategic priorities, we can help make our urban centers more resilient to global shocks such as climate change and urbanization. With the right choices we can create a more sustainable future for a global population that has been burdened by weeks of keeping physically distant, to help us come together to rise above this tragic period. AECOM can help advise on this.

After the devastation of World War II, the world enjoyed an economic boom financed, in part, by the massive need to rebuild large swathes of Europe and to support suffering economies elsewhere. Despite unprecedented hardships, some of the greatest public works projects in history were begun in this period — from the UK's New Towns program, that saw the construction of over 20 entirely new settlements, to President Eisenhower's new Interstate Highway System. The legacy of such projects should serve as an inspiration to today's policy makers of what they can achieve. [WU](#)



Runcorn, one of 20 New Towns to be created in the U.K.



WHEN STIMULUS FUNDING BECOMES AVAILABLE, IT WILL BE MOST IMPACTFUL IF SPENDING BODIES HAVE A COMPREHENSIVE INFRASTRUCTURE STIMULUS PROGRAM TO GUIDE PRIORITIES.

Interstate, Florida, U.S.





ADAPTING TODAY
FOR A NEW TOMORROW

HOW TO REOPEN AIRPORTS IN A POST-CORONAVIRUS WORLD

Coronavirus is unlikely to be eradicated until a vaccine is found. AECOM's global aviation experts **Richard Gammon** and **Bijan Pashanamaei** examine ways the travel industry, and airports in particular, can restore passenger confidence by making travel safe.

The travel industry has been wiped out by the coronavirus pandemic. Passenger traffic at Hong Kong International Airport fell by 91 per cent in March year-on-year. At Frankfurt Airport, the reduction was of 97 per cent ¹ and Heathrow estimates a 90 per cent fall in April ². Some airports have shut down altogether in response to severe restrictions on travel; others, like Heathrow, have concentrated operations into fewer runways and terminals. Cargo, rather than passengers, is now their main business.

It is relatively simple to shrink operations or shut things down. It

is much harder to ramp up activity securely, particularly when the coronavirus is still in our midst. As governments around the world prepare to ease lockdown measures and reactivate their economies, airport operators must begin to consider what steps they need to take to allow a successful and safe reopening of terminals. How can they create a safe environment for thousands of airport staff and the millions of travelers who fly every day?

This is a huge and highly complex challenge, but not an insurmountable one. The overriding goal must be to restore confidence in airports as a safe working and travel environment.

97%

Passenger traffic reduction at Frankfurt Airport in March 2020.

91%

Passenger traffic reduction at Hong Kong International Airport in March 2020.

When considering the risk-reduction measures to achieve this, it might be useful to keep three objectives in mind:

- / The need to reassure passengers that they will be as safe as possible.
- / The need to ensure that measures and processes are as efficient as possible.
- / The need to build flexibility into decision-making: to accept that measures adopted today won't be the last, or may be replaced by others, as the pandemic recedes and our understanding of the illness improves.

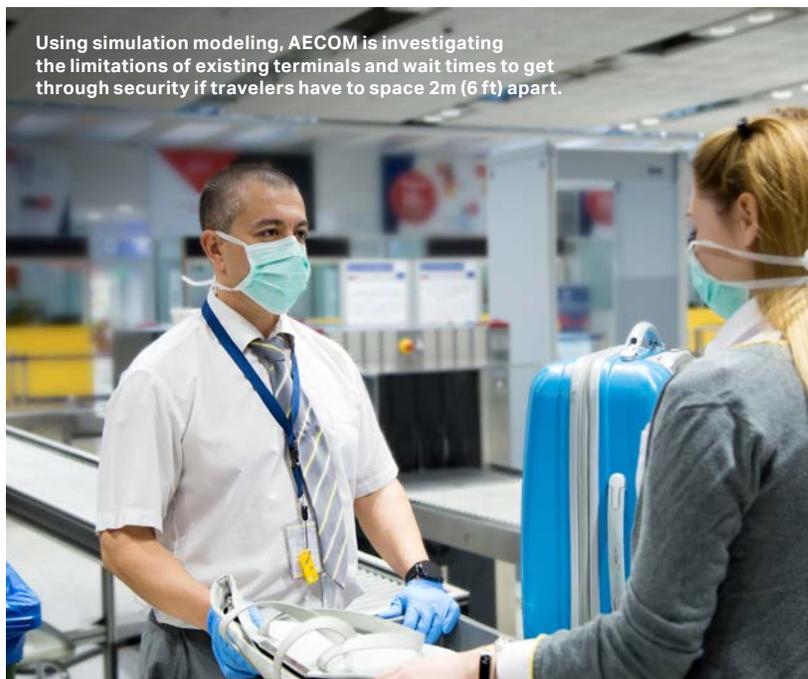
Above all, this will be a learning process. Airport operators have never had to deal with a challenge of this magnitude, so the steps they take to make air travel safer today will be vital for building a more resilient travel industry — one that will be better prepared for future shocks. ➡



AIRPORT OPERATORS MUST CONSIDER MEASURES THAT WILL KEEP AIRPORT TERMINALS CLEAN, PRIORITIZE PERSONAL SAFETY, REDUCE OR ELIMINATE UNNECESSARY PERSONAL CONTACT, AND THAT ALLOW PASSENGERS TO MOVE THROUGH THE AIRPORT AS QUICKLY AND SAFELY AS POSSIBLE.

Conquering the new fear of flying

With governments discouraging all but essential travel during the pandemic, people are understandably anxious. To dispel those fears, airport operators must consider measures that will keep airport terminals clean, prioritize personal safety, reduce or eliminate unnecessary personal contact, and that allow passengers to move through the airport as quickly and safely as possible. For arriving passengers, the aim should be to get them out of the airport as quickly and as safely as possible too.



Using simulation modeling, AECOM is investigating the limitations of existing terminals and wait times to get through security if travelers have to space 2m (6 ft) apart.

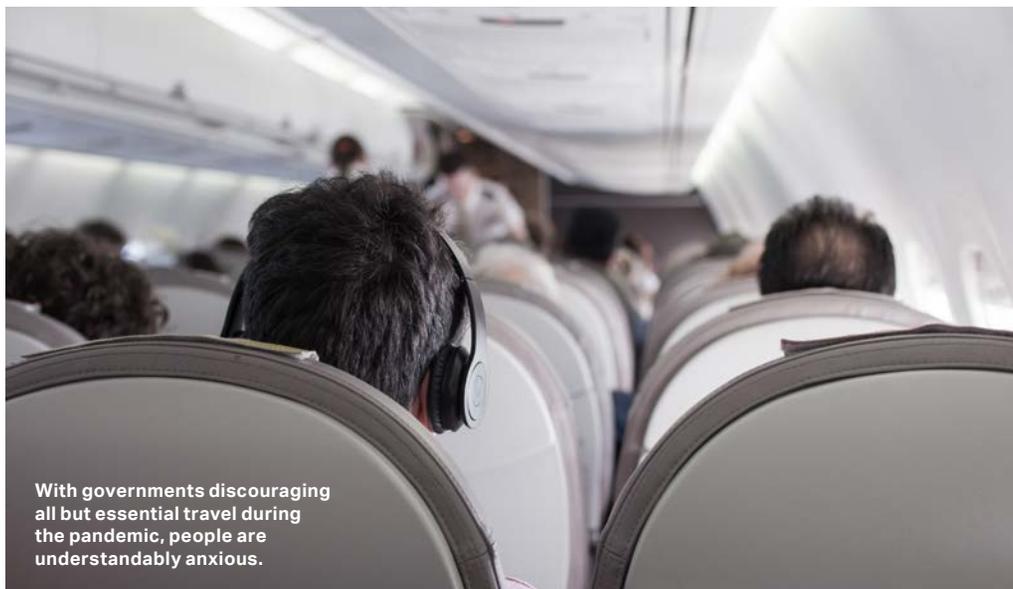
Some form of health screening for passengers prior to travel looks set to be essential. Biometric apps already exist that would allow travelers to send their health data in advance, saving time, although data privacy issues would need to be resolved. Some countries are considering issuing “health passports” or “fit for travel” documents for travelers who have developed immunity. Thermal imaging and temperature sensing technologies could also be incorporated into “screening tunnels” either inside or outside terminal buildings, effectively making them semi bio-secure zones.

It is looking probable that passengers will be required to pass a temperature scan before taking a flight. And if they are, how will body temperatures be taken, and by whom? In one international airport in the US Northeast, where AECOM is advising on reopening strategies, there is considerable debate over whether health checks need to be performed by registered nurses, medical professionals or trained airport staff. Each option has different issues but, because accuracy and reliability are important, most agree that deploying nurses might best help restore confidence in air travel.

Nevertheless, health screening for coronavirus symptoms will not detect asymptomatic carriers. As a result, and until mass testing is available, traveling will involve a certain degree of risk. The key is to progressively reduce the risk of contagion through a combination of measures until it becomes acceptable: a risk that most travelers, on balance, might be willing to take.

Density management

Mathematical models suggest that distancing will not be possible when passenger traffic recovers to 50 per cent-60 per cent of pre-coronavirus levels. Airport operators therefore face a choice: reduce capacity, or improve the management of passenger density and flows. ➔



With governments discouraging all but essential travel during the pandemic, people are understandably anxious.

At another international airport in the US Northeast, AECOM is using simulation and passenger facility modeling to understand the limitations of the existing terminals and the resultant capacity and wait times to get through security if travelers have to space 2m (6 ft) apart. The results, which vary from terminal to terminal, allow the airport to understand how many passengers can be processed per hour in the space available with a modified number and configuration of lanes.

Meanwhile, airport operators and airlines could co-ordinate to flatten out and spread demand during the day in a short-term effort to reduce peaks. Airports could adopt a phased arrival approach, giving passengers a time window to arrive at their terminal. Phased boarding, with groups of passengers held in separate areas, could help reduce both congestion and density at departure gates.

Nevertheless, as travel recovers, physical distancing will be harder to achieve. On board, seating passengers apart may prove economically ruinous. As a result, measures to ensure that the risk of infection progressively diminishes the deeper one is inside the terminal take on added importance.

Will queues become longer?

Not necessarily. Inside the terminal, two factors will largely determine the safety of travel: minimizing the need for physical contact and getting passengers quickly to their departure gates. The onus is on the operator to provide an efficient transit through the terminal.

Several technologies already exist that could enhance this further. They include fully automated self-service baggage drops — a one-step process where a passenger's identity is verified via biometrics; and baggage sanitization stations, using either ultraviolet or fog technologies, for both outbound and inbound bags. This will greatly improve the health and safety environment for baggage handlers. A similar approach could be used for sanitizing carry-on bags and passenger belongings. A broader use of e-passports together with more widespread application and use of biometric data could also assist.

Will coronavirus measures become a permanent feature?

Perhaps. The watchword is flexibility. Airports need to start thinking now at tactical and strategic levels about more passengers and flights. They can't wait until governments begin to lift travel restrictions or widespread international measures are agreed and implemented. Large international hub airports can in the meantime work together to drive global standards and best working practices.

The key will be to treat airport terminals like a filtering system. From outside the terminal doors to the boarding gate, a series of measures — health screens, automated check-ins, baggage sanitation, contactless security checks, among others — ought to progressively reduce the risk of exposure to the virus. If these filters are effective, to the point where operators could be highly confident that the airport environment and population



Several technologies already exist that could enhance this further. They include fully automated self-service baggage drops

are as sterile as possible, then perhaps the need for physical distancing would become less problematic, allowing airport operators to handle higher densities of travelers.

If and when a vaccine is found, none of this will be wasted effort. Much will have been learned about passenger behavior and communication, with changes that streamline the passenger journey. Air travel will be better prepared for the next pandemic as a result. **WL**



AIRPORTS NEED TO START THINKING NOW AT TACTICAL AND STRATEGIC LEVELS ABOUT MORE PASSENGERS AND FLIGHTS. THEY CAN'T WAIT UNTIL GOVERNMENTS BEGIN TO LIFT TRAVEL RESTRICTIONS OR WIDESPREAD INTERNATIONAL MEASURES ARE AGREED AND IMPLEMENTED.

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BUILDING A BETTER CASE FOR INFRASTRUCTURE INVESTMENT

As we look towards recovery, there's a danger that immediate concerns about jobs and growth eclipse social considerations. Infrastructure has an important role to play in getting the economy moving again, but it can also open up new opportunities and improve quality of life for those hurt by coronavirus. To create infrastructure that is not only best in the world but best for the world, AECOM's **Lara Poloni** argues social impact should be a key driver for investment, in addition to the traditional measures of economic return and job growth.

In the American city of Atlanta, an abandoned railroad track turned pedestrian path is connecting communities and erasing a redline that once separated them. In the United Kingdom, a new crosstown rail line is not only expected to improve the commute into London, it may also help some residents live longer by connecting poorer parts of the city with the economic opportunities in the center.

In China, restoring a river running through the center of Nantong is enhancing the sustainability of this industrial port city and improving the wellbeing of the local population. What connects these projects? Each one delivers "social impact" dividends and addresses pressing challenges that extend value beyond the more traditional economic benchmarks guiding most infrastructure investment today. ➡



IN THE BELTLINE PROJECT IN ATLANTA, GEORGIA, 22 MILES OF ABANDONED RAILWAY TRACKS CIRCLING THE CITY'S URBAN CORE ARE GIVING WAY TO A BIKING AND PEDESTRIAN LOOP.



The BeltLine project in Atlanta, Georgia, U.S.

Infrastructure's value as a driver of economic growth is a tried and tested measure of success. Potential economic returns are almost always cited in building the case for investment. Indeed, governments looking to reboot economies when the coronavirus pandemic eases are likely to turn to infrastructure precisely for its strengths as an economic multiplier.

In making the case for infrastructure, social benefits tend to fit the 'nice to have' category. In part, this is because they are harder to measure — making success harder to claim. But when it comes to extending value for communities looking to rebuild and adapt to our new normal, social returns are essential.

If the crisis prompts a re-appraisal of societal concerns — as we think it will — it is likely that social needs will get more attention in future.

According to psychologist Abraham Maslow's influential theory on the hierarchy of needs, many people will shift toward a greater appreciation of benefits such as protecting public health, correcting social inequities, improving access, boosting quality of life, and enhancing wellbeing.

The move to consider social value has been building for some time due to a variety of factors. Moved to action by climate change worries, the public has been applying greater pressure on corporations and governments to do

\$5bn

Atlanta's BeltLine has generated \$5 billion in new commercial and residential development in its first decade.

right by society in their investment decision-making. Companies are finding that a strong environment, social and governance (ESG) proposition can drive value and safeguard long-term success. And governments — mindful of the inextricable link between physical infrastructure and public benefits — are also setting terms during the procurement process that require greater social value considerations, like developing new skills in local populations.

In the wake of tragic and massive fires and hurricanes around the world, cities have been increasing investment in the resilience of physical systems, a proper assessment of which covers social as well as environmental pressures. Dealing with coronavirus is testing some of those systems to the maximum.

In the future, what's needed is a greater focus on developing standardized, accepted measurement tools to better quantify direct and indirect social impacts. Environmental rating systems provide an organized framework and standardized metrics for measuring performance. If a similar system were developed for social impact, it would offer insight into, extend advocacy for and showcase projects that are not just best in the world, but best for the world.

Measuring social impacts: the long game

In the BeltLine project in Atlanta, Georgia, 22 miles of abandoned railway tracks circling the city's urban core are giving way to a biking and pedestrian loop as part of a revitalization plan that will connect 45 neighborhoods, add jobs, affordable housing and 2,000 acres of new and upgraded parks.

AECOM provided engineering and design services for this highly touted 25-year urban landscaping project that embraces principles aligned with triple-bottom line reporting, an accounting framework that focuses on social and environmental concerns as much as profits. Established in the early 1990s, and the concept has given rise to other measurement frameworks, including social return on investment (SROI) and ESG.

Beyond generating \$5 billion in new commercial and residential development through its first decade, project backers see the BeltLine's continuing potential in not just spurring redevelopment, but in easing divisions of class and race, supporting small businesses, promoting healthier living for residents and improving access.

The challenge will always be in measuring success: how do you assess the true benefit of a project on people's lives over time, in driving wellbeing, or in generating meaningful social change? ➡

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IF YOU THINK ABOUT THE LONG GAME AND HOW YOU'RE BUILDING CAPACITY, ENABLING ORGANIZATIONS TO STAND ON THEIR OWN FEET AND DRAW DOWN ON THE RESOURCES THAT THEY NEED TO MAKE THAT HAPPEN, YOU'RE GOING TO BE IN A GREAT PLACE.

**NATHAN GOODE,
DIRECTOR OF THE SOCIAL VALUE PORTAL**

£42bn

London, the Crossrail project is expected to generate a £42 billion benefit to the UK economy when it's completed in 2021.

In the UK, the Social Value Portal is bringing additional rigor and consistency to the task of evaluating different strands of social impact using financial and non-financial information and drawing in the public-and private-sectors, third parties and even competing professional services companies. Work to assess the whole-life value of buildings and infrastructure, not just whole-life costs, plays to sustainability standards set by many governments, especially in Europe and Asia-Pacific.

What's clear is that helping clients land on the right measurement systems requires transparency, data, a holistic view and patience. Creating a common way of talking about and reporting social value can be a driver of change, while encouraging collaboration, authenticity and openness.

"You should be looking at social value in a lifecycle sense," says Nathan Goode, director of the Social Value Portal. "We're on a journey and looking at social value in an integrated holistic way is relatively new ... If you think about the long game and how you're building capacity, enabling organizations to stand on their own feet and draw down on the resources that they need to make that happen, you're going to be in a great place."

Value judgements

In London, the Crossrail project is expected to generate a £42 billion benefit to the UK economy when it's completed in 2021. In addition to this headline figure, the benefits commonly touted include offering 1.5 million additional people access to central London within 45 minutes.

But improving rail service doesn't just mean saving commuting time. A University College London research project suggests it can also improve life expectancy through greater access to services and opportunity. The 2012 study determined that life expectancy for a man in Westminster, one of the most affluent sections of London, was 77.7 years. However, board the Underground in Westminster and travel east seven miles (6 stops) and you find yourself in Canning Town. Life expectancy for a man there? 71.6 years.

Can you put an economic value on seven years of someone's life? Of course not. Those who attempt to do so have been equating value with monetary worth. With a proper way of measuring social impact, this confusion would be less likely to arise. ➔



TRADITIONALLY, INFRASTRUCTURE INVESTMENT HAS BEEN KEY TO GETTING ECONOMIES BACK ON THEIR FEET.

Quality of life

In China, the Nantong Eco-Corridor project began with the need to rehabilitate the wetland ecosystem of the Yangtze River delta region, disrupted after many years of rapid industrialization. Our infrastructure-oriented approach resulted in improved soil quality that protects native vegetation, but by doing so we created social benefits too. Recreation activities reconnected residents with nature and promoted a healthier lifestyle for visitors and locals, and better integrated homes and workspaces supported sustainable growth.

When this project is judged in the future, we believe it is these social impacts that will stand the test of time.

The time is right for change

Far from a great leveler, the coronavirus is amplifying existing inequalities. Those with the least secure jobs and tenure have been hit hardest and will find it most difficult to bounce back.

We should seize this moment as an opportunity to help them. Around the world, interest rates are at historic lows and governments are weighing trillions of dollars in stimulus programs. Despite the crisis, tens of billions of private sector dollars are available in capital globally.

Traditionally, infrastructure investment has been key to getting economies back on their feet. In their selection of projects, decision makers should not lose sight of social objectives. If we are to emerge from this pandemic stronger, we must ensure that those who were already disadvantaged before the crisis are not left behind.

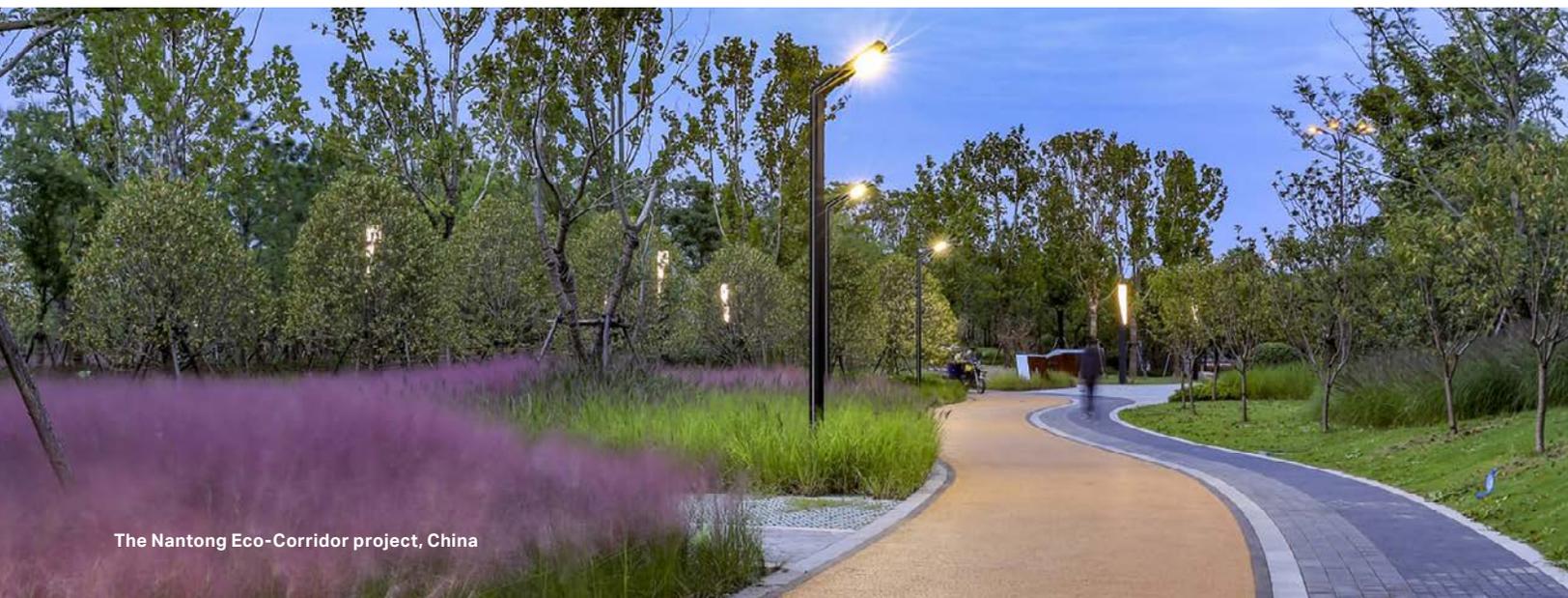
In the long term, our industry can play an advocacy role in advancing a universally accepted measurement scheme useful for government, the private sector and investors alike, and by focusing attention on projects and innovative approaches that incorporate social impact thinking

— from the design and planning stages, to delivery and throughout the project life-cycle.

This process should start now: creating a common way of talking about and reporting social impact can be a driver of change.

Blending competing models in pursuit of an easily understood standard should become the objective, as well as in attaching measurement to setting goals for what infrastructure ought to achieve — including benchmarks for job creation, social equity and accessibility. As a McKinsey & Co. report in January 2020 affirms, gains from infrastructure are fully realized only when projects generate tangible public benefits. Increasingly, those benefits include everything from building resiliency against climate change to reducing inequalities in our cities.

“The business case for infrastructure projects should consider social and environmental benefits,” says Stephen Engblom, AECOM’s Global Cities Director. “Rallying support for these projects is easier if the community understands not only the dangers that these projects seek to prevent, but also the benefits they can enjoy.” 



The Nantong Eco-Corridor project, China



PAYING IT FORWARD

WHY RESILIENCE IS A RISING PRIORITY

From the coronavirus to severe weather events, achieving resilience has become an urgent and strategic imperative for cities, writes AECOM's **Stephen Engblom** and **Caitlin MacLean** from the Milken Institute.

Even before the coronavirus crisis, the idea that we need to make our towns and cities more resilient was growing. From aging and deficient infrastructure to the challenges of climate change and population growth, we are clearly under-prepared to meet the increasingly unpredictable challenges of today. The pandemic has highlighted some of these weaknesses, but it also brings with it an opportunity to make our infrastructure fit for the future.

As a global society, we have spent the last decade identifying potential shocks and stresses, as well as strategies for addressing them.

However, insufficient budgets, lack of political will and weak public support have meant many of these resilience strategies were not implemented. Capital sources exist, but securing the right blend of capital and approving financing schemes amid other competing demands has proved challenging. Tackling the coronavirus pandemic is adding further complications.

The need to address the funding gap led AECOM to collaborate with the Milken Institute to ask what can be done to improve the ability of our cities to overcome the challenges of an increasingly uncertain world and continue to grow sustainably.

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AS A GLOBAL SOCIETY, WE HAVE SPENT THE LAST DECADE IDENTIFYING POTENTIAL SHOCKS AND STRESSES, AS WELL AS STRATEGIES FOR ADDRESSING THEM.

The Financial Innovations Labs that we convened¹ brought together key stakeholders, decision makers and financial experts on resilient urban infrastructure. In this article, we highlight lessons learned and provide insights on how these can be applied in other cities.

In New York, we discussed Lower Manhattan Coastal Resiliency, the City's plan to adapt Lower Manhattan to climate change, for this generation and the next; in Los Angeles, we examined improvements in public transport; and in London, we addressed the shortfall in housing provision. In each case, described more fully below, we developed ways to pivot from talk to action by going beyond traditional resources, working across silos, and rethinking how we compile the necessary capital stacks. While all of these labs were held prior to the outbreak of coronavirus, the funding challenge remains. ➔



IN 2012, SUPERSTORM SANDY LED TO THE DEATHS OF MORE THAN 40 PEOPLE AND CAUSED SIGNIFICANT DAMAGE AND ECONOMIC LOSSES TOTALING US\$19 BILLION² FOR NEW YORK CITY AND THE U.S. EAST COAST.

Environmental resilienceto natural shocks

In 2012, Superstorm Sandy led to the deaths of more than 40 people and caused significant damage and economic losses totaling US\$19 billion² for New York City and the U.S. East Coast.

The storm demonstrated the extreme vulnerability of one of the world's key economic and cultural centers that the public and private sectors have been trying to address since, even as sea and groundwater levels continue to rise.

In March 2019, the City released its Lower Manhattan Climate Resilience Study.³ Developed by the City, with support from a large consultant team led by AECOM, the study identified US\$500 million of near-term climate adaptation projects and a long-term Climate Resilience Master Plan for the Financial District and Seaport.

In the absence of additional federal and state funding, carrying out the Climate Resilience Plan will require new and innovative funding and financing mechanisms.

The Milken Institute, in collaboration with AECOM, examined a variety of funding and financing options that could be applied at different scales. Various options for raising money through a bond program could be applied at a city level. At the regional or state level, more funds could be collected through a two per cent surcharge on insurance policies, which could be saved in a trust fund managed by an independent entity. In addition, the city could include revenue-raising models in its plans, from selling private development rights to utilities to surcharges that are income dependent.⁴ The goal was to map out the right mix of capital sources and investment types to bridge funding gaps.

The Lab found that funding resilient infrastructure in the future will likely require alternative financing plans that pool from a range of public and private funding sources.

Mobility — addressing the unjust impacts of poor transportation networks

In Los Angeles, a city long recognized for its car culture, the greatest challenge to overall resilience is mobility. As part of our Financial Innovations Lab series, we examined the need to improve public transportation infrastructure to serve the needs of a growing population while improving air quality and reducing emissions.

California's population is expected to grow from just under 40 million today to almost 50 million by 2050.⁵ Residents are so fed up with traffic and poor air quality that they are willing to pay for the necessary improvements in public transport. In 2016, Los Angeles residents voted to finance a \$120 billion mobility improvement program known as Measure M.

The centerpiece of the regional rail network, Union Station, is key to interregional and local transportation strategies. Required improvements include a new passenger concourse and other amenities expected to cost as much as \$2.5 billion — a total not covered by Measure M.

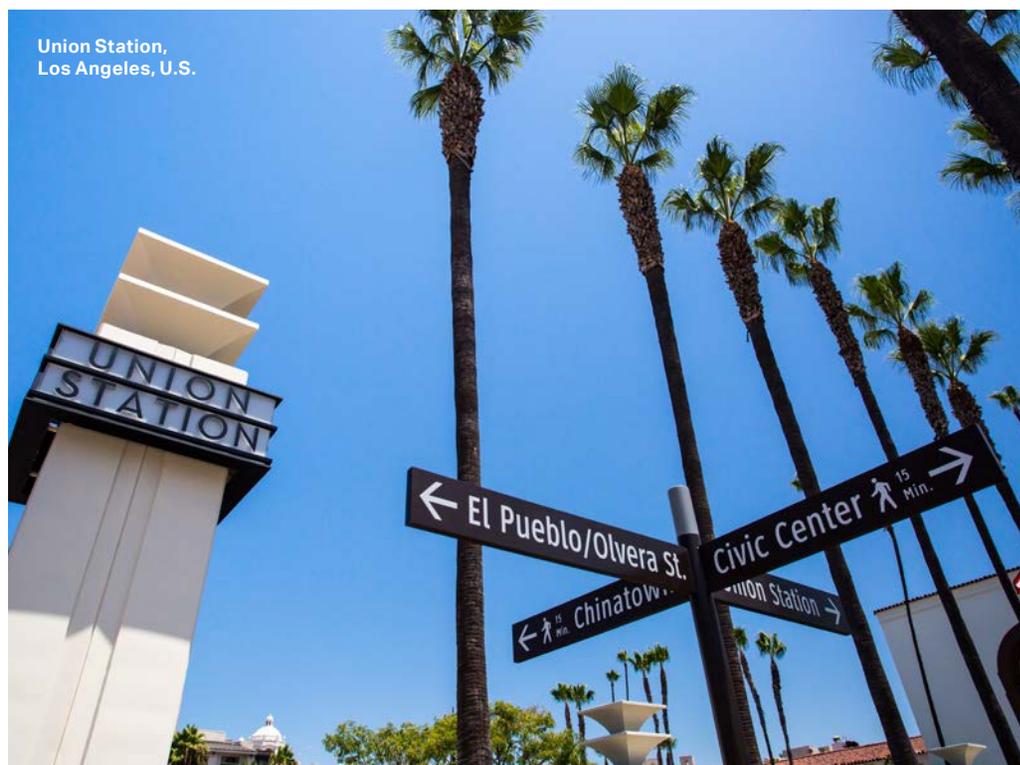
Public and private-sector stakeholders at the innovation lab in Los Angeles discussed several strategies, from tax increment financing to nearby commercial development. They also encouraged the project's sponsor to re-examine capital and operating plans to make them less prescriptive, widening the sphere of potential funding.⁶ Since then, the pandemic is likely to influence how government advances these transportation projects. →



Devastation caused by Superstorm Sandy in 2012 to the U.S. East Coast.

50M

California's expected population by 2050



Union Station, Los Angeles, U.S.

AECOM's INNO solution, developed in partnership with Rogers Stirk Harbour + Partners (RSHP).



Affordability — ensuring long-term viability of our cities by accelerating access to affordable housing

Our Financial Innovations Lab in London looked at resilient housing strategies to address a housing crisis caused by decades of underdelivering the number of homes people need. The impact of this crisis is a housing market that excludes many, catering to higher-end developments over genuinely affordable housing stock for the low- to middle-income market.

Current practices result in long lag-times and slow delivery: across Greater London and the city region, an average of 75,000 homes have been built annually in the last decade. If this rate of delivery remains consistent, this will result in a shortfall of as much as 800,000 homes by 2026, and more than one million homes by the end of the following decade.

Optimism exists that modular construction has the potential to solve the supply shortage. Today's off-site manufactured homes are far from 'prefabs' and system-built blocks that significantly increased housing supply in the 1970s. Digital tools and precision engineering are delivering high-quality, eco-efficient homes with lower running costs for residents. Not

only does assembly within a factory environment mean developments can be delivered much faster than traditional building methods, the system also avoids noise and waste that accompanies traditional onsite construction — not to mention the delays caused by adverse weather or access conditions.

AECOM's INNO solution is one of the most advanced modular systems, developed in partnership with Rogers Stirk Harbour + Partners (RSHP), to initially address the housing shortage across the UK. Incorporating manufacturing and process engineering experts, projects progress from concept, design, assembly to construction on site, integrating the entire supply chain.

One of the first projects to be delivered is for YMCA Thames Gateway in Romford, East London. The 39 single-occupancy units support YMCA's independent living program, enabling individuals to move on from supported living. All 39 units are assembled off site and fully fitted out in factory conditions. It takes five days to complete a one-bedroom unit with delivery on site accelerated. Scalable to meet UK housing market demands, the INNO system could easily be adapted for international markets. ➔



GETTING STIMULUS READY

All of the programs and projects discussed in this article are of strategic importance. However, schemes such as these are often long term, involving multi-agencies and cross jurisdiction. This could mean they risk being overlooked by decision makers when determining what programs qualify for stimulus programs. To avoid this, stakeholders should consider:



STIMULUS CHECKLIST ✓

ECONOMIC

- / Direct job generation
- / Local impact/spending multipliers
- / Targeting highly impacted clusters and industries
- / Encouraging transformative capital investments
- / Driving growth in disadvantaged areas and regions
- / Dispersing benefits to a large pool of users

ENVIRONMENTAL

- / Resilience and disaster preparedness
- / Long-term stresses, greenhouse gas, air/water quality
- / Shocks, climate events, future pandemics, terrorist attacks

EQUITY

- / Prioritizing communities of concern
- / Community support for project
- / Access to recreation/open space
- / Access to jobs
- / Access to housing
- / Workforce training and upskilling

FUNDING AND FINANCE

- / Federal, state, regional, local grants
- / Public financing (debt)
- / Self-generated TIF, BD/SSA, toll, land sales, etc.
- / Private investments, public-private interaction
- / General Funds

REGULATORY

- / Design or concept well progressed
- / Legislative or regulatory approvals
- / Active community and stakeholder engagement
- / Environmental permitting
- / Local planning efforts

GOVERNANCE AND IMPLEMENTATION

- / Project champion and sponsor
- / Interagency support
- / Available workforce and supply chain
- / Special purpose vehicles
- / Risk mitigation (track record, procurement, oversight)

Making our future resilient

The full impacts of the current pandemic are yet to be fully understood. What we do know is that the need to address our infrastructure inadequacy in the face of extreme weather, political and social unrest has not gone away. If anything, the need for resilience is now even stronger.

In many cases, resilience strategies have been prepared, but gathering enough money to implement them has proved difficult. Accelerated

funding strategies may now be possible with the stimulus packages being prepared by governments around the world. When this stimulus funding is harnessed correctly and combined with new and innovative approaches, such as those highlighted in our Financial Innovations Labs, this could be the lightning rod needed to address the large-scale and complex resilient infrastructure projects that are required. [ML](#)

Cristian Bevington, Jon Dearing, Garrett Harper, Joel Sonkin, and Joy Woo contributed to this article.



PRIVATE FINANCING OF INFRASTRUCTURE SERVING THE PUBLIC INTEREST AS WELL AS PROFITS

When it comes to financing long-term infrastructure projects, the private sector has a role to play. AECOM's **Shamit Gaiger** and **Samara Barend** argue that private investors need to show how they will serve the public interest — not just with policymakers, but also with taxpayers and those who stand to benefit from the infrastructure.

To help the world rebuild from the coronavirus pandemic, government stimulus funding is likely to come with incentives to encourage private financing of infrastructure and partnerships. The private sector has an important role to play in the recovery, but to unlock private investment we must first address the waning appetite for public-private partnerships prior to the crisis.

On the public side, poorly designed projects that proved expensive to maintain attracted criticism and rightly so. But industry,

too, had become wary of involvement in large projects due to the amount of investment involved and the accompanying risk. Dialogue between project promoters and industry trying to find a way forward is taking place, but outcomes aren't guaranteed.

To find a way forward, this article argues that public- and private-sector interests need to come together. If objectives and outcomes are aligned, both parties can convince the public — as they need to — of the value to their communities of privately financed projects. The way public and private sectors have cooperated to deal with

the coronavirus pandemic should hopefully mean both sectors have a better appreciation of each other's interests, which is a good start.

Paying for infrastructure

Private financing of public infrastructure is a well established concept. A stele from Eretria tells of a contract established in 300 BC between the city and a foreign contractor, Chairephanes, to drain lake Ptekhae.¹ The contractor covered all expenses and paid a lump sum to the city in exchange for the exclusive rights to exploit the reclaimed land for 10 years.

Since this first known example of a public-private partnership, private financing has evolved into an innovative project delivery method that is often faster, cheaper and better than traditional design-bid-build delivery.

By spreading the cost of infrastructure over the lifetime of an asset, it's often faster to assemble funds to start construction. It's also a way to access the skills, discipline and expertise of the private sector, with benefits in terms of cost efficiencies, innovation and efficient risk-management. →

In well-designed private financing arrangements, accountability is built-in: payment contingent on performance tends to reduce cost overruns and schedule delays, particularly if there are fines or penalties involved. Multi-year contracts can encourage construction quality when the private sector is responsible for well-defined maintenance obligations many years down the road. The same cannot be said for most purely public-funded projects. These benefits should outweigh the higher borrowing costs for the private sector, particularly today when interest rates are low for everyone. At AECOM, we've been involved in over 600 private financing initiatives, including the largest PPP undertaken in the U.S., New York's LaGuardia airport redevelopment. From our perspective, it shouldn't matter whether the financing is public or private in origin. What matters is getting the conditions right so that the project serves the public interest.

Conditions for success

Below we share insights on how to unlock private investment in infrastructure in a way that delivers value for money to taxpayers, communities and shareholders, based on our experience over the past 30 years working on projects in Asia, the Middle East, Europe and the Americas.



FROM OUR PERSPECTIVE, IT SHOULDN'T MATTER WHETHER THE FINANCING IS PUBLIC OR PRIVATE IN ORIGIN.

1/ CLARITY OF PURPOSE

There is increasing need to be clear on the specific circumstances where private financing works best. This is important not just for the immediate needs of infrastructure, but also for the duration of the financing agreement.

In our experience, private financing is most useful when it comes to complex, long-term projects that require expertise that the public sector doesn't have in-house. Infrastructure is being redefined by new technologies such as artificial intelligence, 5G networks, the Internet of Things — areas where the public sector may lack experience. Green infrastructure projects, particularly those involving the decarbonization of the economy, are also good candidates for private sector financing. For projects where infrastructure functionality is likely to change over time, private finance arrangements must have significant flexibility built into the contract. In Europe, this hasn't always been the case.

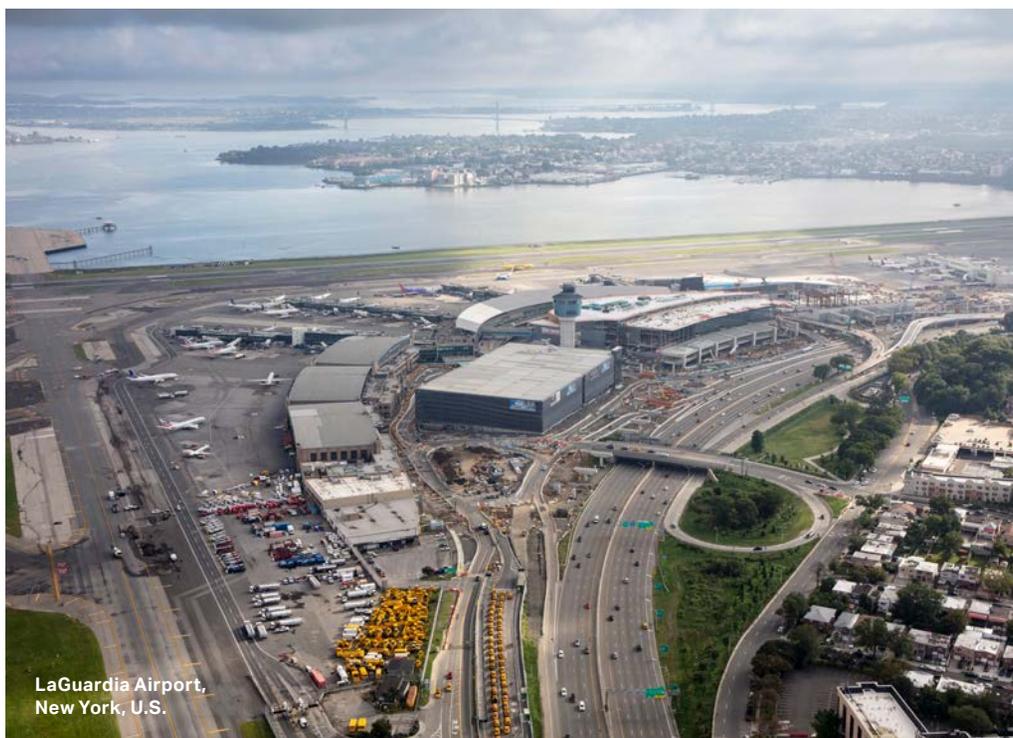
2/ ALIGNING PUBLIC AND PRIVATE OBJECTIVES

The public and private sectors can have different motivations when it comes to infrastructure projects. Generally speaking, the former is focused on enabling public benefits such as the provision of goods and services such as water, transport, education, or minimizing harms — whether they are environmental, disease-related or crime-linked — as well as unlocking economic growth and jobs. For the private sector, funding decisions must include an assessment of the anticipated financial returns of a project, balanced against the estimated risks, the company's financing capacity and overall strategy.

In reality, however, public and private interests can align. As the coronavirus crisis has shown, delivering tangible socioeconomic benefits is in everyone's interest and there needs to be a balance of expected returns from the investment and an appropriate balance of risks and benefits.

This means that the private sector needs to consider from the outset how their involvement can be beneficial to the people the infrastructure they are investing in is intended to serve. Leading businesses are addressing the most challenging problems of our times, from climate change to chronic disease, social exclusion, and material poverty. By aligning public and private resources and objectives, private financing has a better chance of being accepted by taxpayers and government.

A first step could be to review private financing contracts to ensure they have enough flexibility. Private companies do want to lock in returns — but if they are allowed to earn a little more upfront they should be willing to consider a little more flexibility long term. If the short-term return on investment is clear, flexibility in contracts is something both parties could benefit from. →



LaGuardia Airport,
New York, U.S.

3/ UNDERSTANDING RISK

Once objectives are aligned, a common understanding of risk is crucial. Although private financing costs more than direct public funding, it is financially worthwhile because risk is transferred to investors — at least that's the idea.

Realistically however, risk cannot fully be transferred to the private sector. A case in point is rail infrastructure, where there would be an outcry if government allowed services that people rely on to shut down. Both parties should be transparent about this and price it into the contract. In structuring privately financed infrastructure schemes, risks should be allocated appropriately between the various parties according to who is best able to manage them. This party should also be best able to assess and price the risk. Incentives for the proper management of risk — including keeping to budget, delivering on time, and ongoing performance — should be included from the outset.

From the private sector perspective, the capacity and willingness of the industry supply chain to accept risk must also be considered. The collapse of facilities management and construction services company Carillion should serve as a lesson. Cost overruns on three public sector construction contracts were among the UK company's biggest problems, with some blaming risky contracts for the company's demise.²



THE PRIVATE SECTOR NEEDS TO STEP UP WHEN IT COMES TO PROMOTING THE BENEFITS OF THE INFRASTRUCTURE THEY DELIVER.



IN STRUCTURING PRIVATELY FINANCED INFRASTRUCTURE SCHEMES, RISKS SHOULD BE ALLOCATED APPROPRIATELY BETWEEN THE VARIOUS PARTIES ACCORDING TO WHO IS BEST ABLE TO MANAGE THEM.

4/ WINNING PUBLIC OPINION

Long term, if private financing is going to be successful and a viable option for delivering projects, public opinion will need to be supportive. To address critics who claim PPP/PFIs enrich investors at taxpayers' expense, the onus is on the public sector to ensure that contracts are well designed and in public interest.

At the same time, the private sector needs to step up when it comes to promoting the benefits of the infrastructure they deliver. If people's wants and needs are met, they are less likely to complain about so-called profiteering.

Benefits must be communicated from the outset of discussions, and

engagement should be ongoing through the lifetime of the project. This is the responsibility of both sides, although private businesses can do more in this area. The onus post coronavirus will be on private firms to show how they are contributing to the nation's prosperity through the infrastructure projects they deliver.

Communication should be focused on the needs of the end user. Often infrastructure providers promote the latest technological solutions or innovations rather than the impacts on people's lives, such as the number of jobs created or environments improved.

Measuring social benefits would also help. A more robust and standardized framework, method, and set of indicators for capturing and quantifying the full range of infrastructure project benefits — social as well as economic — could improve the cost-benefit assessment of privately financed projects. →



CLEAR ACCOUNTABILITY AND A REALISTIC ALLOCATION OF RISK IS VITAL TO WIN PRIVATE SECTOR APPROVAL, WHOSE INTERESTS MUST BE ALIGNED WITH PUBLIC SECTOR NEEDS.

Unlocking private financing

Infrastructure investment is going to play an important part in the economic recovery, but the public sector cannot do it alone. Given the costs of dealing with the coronavirus pandemic, some projects simply won't happen without private financing.

To unlock private capital for infrastructure projects, the conditions need to be right on both sides. Clear accountability and a realistic allocation of risk is vital to win private sector approval, whose interests must be aligned with public sector needs.

At the same time, the users of infrastructure — who ultimately are the people who pay for it — should be carefully considered. The private sector needs to work with the public sector and communities, building an understanding of the purpose, aligning objectives and delivering tangible material benefits to society and communities. Because of the politically sensitive nature of such investments, the benefits need to be properly assessed and communicated. Only then will we see a viable and positive future for private financing.

Denise Casalino, Alton Chow, Scott Davis, Dr. Raju Gottumukkala, Garrett Harper, Edouard Hiley, Mohan Killada, Bruce McCuaig, Jonathan Pressdee, and Marko Prgin contributed to this article.



HYDERABAD METRO RAIL PROJECT

WORLD'S LARGEST ELEVATED METRO UNDER PPP MODE

The Hyderabad Metro Rail Project is the largest of its kind in the world built under a Public Private Partnership (PPP) framework. The network is about 69 kilometres long, comprising 58 stations and 3 interchange stations. Project cost is estimated to be INR 16,375 crore (\$US 3.3 billion), comprising INR 11,478 crore (\$US 2.3 billion) in loans and INR 3,439 crore (\$US 0.7 billion) in equity. The government of the state of Telangana provided land for commercial development.

The project had strong support from the beginning. The client, HMRL (Hyderabad Metro Rail Limited) wanted the project to succeed, and the concessionaire, LTMRL (L&T Metro Rail Hyderabad Ltd.), created a robust project monitoring framework. Factors that ensured the project's success included stakeholder consultation, the ability of the concessionaire to access funds, competitive and transparent procurement, a strong consortium, and appropriate risk allocation.

As the concessionaire's engineer, AECOM contributed in several different ways. We devised a modular standardised station and structural design that allowed use of precast elements, saving time and cost. Design and quality control efforts were greatly reduced on account of this standardisation, as will maintenance costs be in future.

We optimized land requirements to minimize acquisitions and demolitions. This saved the client costs and was key in winning public support. The team faced several challenges, including traversing narrow lanes with reduced right of way. To remedy this, we used the latest construction methods, such as the balanced cantilever method, to drastically reduce the station's structural footprint.

The stations were designed as hubs of public life and nuclei for urban development, with multiple access points connecting adjoining properties at the concourse level and retail areas. The stations have a modern look and comfort amenities that have proved strong as a retail draw.

The Hyderabad Metro has proved a critical success, both with the public and through the hundreds of national and international awards it has won. [WL](#)



NET ZERO HEROES

EXEMPLARY PROJECTS WINNING THE BATTLE ON CARBON REDUCTION

From the city of Palo Alto in California, to the Environment Agency in England, and the city of Christchurch, New Zealand, ever more organisations are committing to reduce their carbon emissions. Taking inspiration from the new technologies and fresh thinking making these goals achievable, AECOM's **Robert Spencer** and **Claire Bonham-Carter** examine projects that could have a huge impact on the health of our planet — if implemented more widely.

The Paris Agreement on climate change commits signatories to limiting global warming. To meet their goal, the Intergovernmental Panel on Climate Change (IPCC) estimates that carbon emissions need to be reduced to zero by 2050. A growing list of countries, cities and corporations are signing up to this target, or promising to do more: Microsoft,¹ for example, plans to become carbon negative in 2030.

To put the brakes on the climate crisis, ten years is a very short timeframe. But thanks to advances

in technology, which are bringing down the price of renewables and increasing energy efficiency, we believe a sustainable energy future is in reach. Getting there is no easy task, however: it will require incentives, targets, roadmaps, and creative thinking.

For his recent documentary film 2040, award-winning director Damon Gameau travelled the world looking for working solutions that could help improve the health of our planet. Similarly, we looked across our business for examples of projects at the vanguard of creating a carbon neutral and liveable world.

We have identified five areas where reducing infrastructure-related emissions could have a huge impact. Naturally, this includes energy, buildings and transport, which in the US together account for around 70 per cent of carbon emissions.² Also fundamental to the challenge are so-called nature-based solutions that protect and restore natural ecosystems that absorb carbon emissions and enhance resilience by, for example, reducing rainfall runoff and the impact of flooding. Finally, there's a need to cross boundaries — looking for solutions outside the boxes that constrain our spatial imaginations. ➔



MOMENTUM FOR CHANGING THE WAY WE PRODUCE, CONSUME AND STORE ENERGY IS INTENSIFYING.

ENERGY

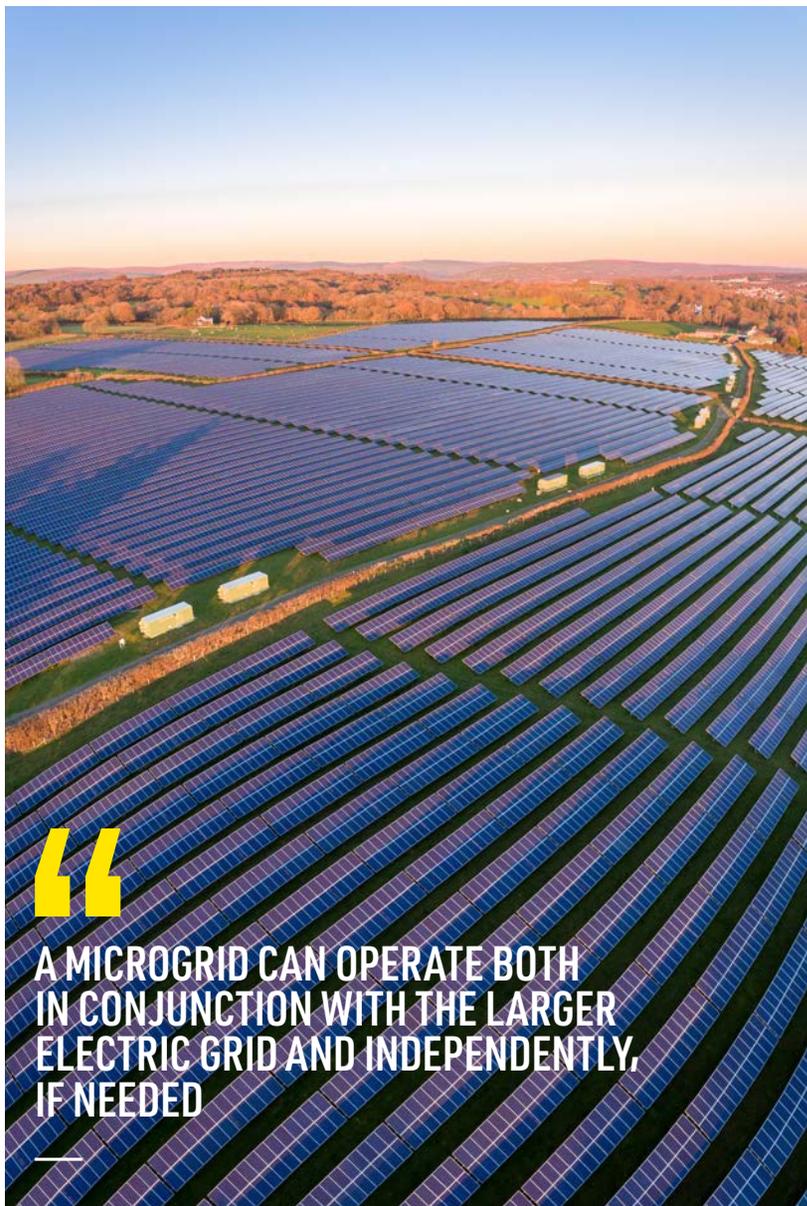
Momentum for changing the way we produce, consume and store energy is intensifying. In northern Illinois, local electric utility ComEd is working with customers to identify ways that resilient energy infrastructure can benefit communities, combat the effects of climate change, and improve daily life.

In Bronzeville, a neighborhood just south of the Chicago Business District, ComEd is constructing the first utility operated microgrid cluster. A microgrid can operate both in conjunction with the larger electric grid and independently, if needed, due to the distributed energy resources like solar PV and energy storage that power it.

Designed to harness on-site renewable resources, the microgrid will serve an area that includes critical city facilities, such as Chicago's public safety headquarters, schools, and libraries. It is also designed to enable the study of how microgrids support the integration of clean energy onto the grid and increase grid security to keep power flowing even during extreme weather or a catastrophic event.

The microgrid is a key component of ComEd's Community of the Future Initiative, focused on resilience, decarbonization, inclusive economic growth, and STEM education. Several STEM education programs are underway, aimed at helping high school students develop crucial skills, cultivate an energy-saving mindset, and receive career guidance and opportunities.

ComEd is testing solutions that connect infrastructure with daily life in the community. This includes new technologies that make the grid more sustainable and resilient, and new business models that give residents and businesses more control over their energy use.



A MICROGRID CAN OPERATE BOTH IN CONJUNCTION WITH THE LARGER ELECTRIC GRID AND INDEPENDENTLY, IF NEEDED

BUILDINGS

When it comes to tall buildings, the first principle of physics prohibits their ability to achieve completely carbon neutral outcomes within the site boundary — but they can still try. With real estate group Mirvac, we're planning a 35-level office building in sunny, subtropical Brisbane, Australia, that is fully electrified with an energy intensity of 64.5 kWh/sqm/yr (in comparison, an average minimum compliance office building in this geography might consume over 130 kWh/sqm/yr). The electrified approach to the 80 Ann St project gives Mirvac the ability to source renewable energy via commercial arrangements such as energy supply agreements (ESAs).

Not only that but for 25 per cent of the year, multiple floors of the building

will maintain comfortable working conditions using mechanically assisted natural ventilation — no small feat in this subtropical climate. To limit the need for heating and cooling, the building's façade limits the transfer of solar radiation and automatically opens panels under the right conditions. Light-filled spaces with Australian native plant species also offer users and visitors a breathable space to interact with nature, encouraging health and wellbeing benefits. Greenery continues up the rise of the tower through planting along vertical spines.

In its design, AECOM targeted carbon neutrality, 6 Star Green Star rating (World Excellence), 5.5 Star NABERS Energy rating, 4.5 Star NABERS Water rating, and WELL Platinum. ➔

64.6
KWH/SQM/YR

80 Ann St., Brisbane, Australia, energy intensity

130
KWH/SQM/YR

Average minimum compliance office building in the same geography

TRANSPORT

The idea of driverless cars has been around since at least the 1960s, when a sensitive self-driving Volkswagen Beetle called Herbie won cinemagoers hearts in the Disney classic *The Love Bug*. As connected digital technology makes this futuristic concept a reality, however, it's becoming clear that the potential is much more than a hands-free driving experience. The real potential of autonomous vehicles is about moving towards a collective and more efficient transport experience that would reduce the number of vehicles on roads and curbsides. When coupled with the electrification of vehicles and the greening of electric grids, the potential to reduce carbon emissions is enormous.

The future of mobility is ACES (Automated, Connected, Electric, Shared). Each of these elements will impact in different ways, and getting the combination right will ultimately determine the carbon credentials of the system. In other words, it's the management of the technology that's important, not the technology alone.

Transport systems across the world are already using artificial intelligence and digital sensors to help analyse the millions of pieces of data being generated relating to demand, delays and constraint issues across their networks. Soon they'll be able to respond in real time with increased capacity, timetable changes and updates to passengers. The process

could be so seamless that there would be little need for an individual car. Those needing to travel will summon the most appropriate means of electric, connected and autonomous transport from a Mobility-as-a-Service (MaaS) provider summoned by app — from an individual pod to a shared vehicle accessed at a mobility hub. If the system works efficiently, it could mean the days of individually-owned private vehicles — with the cost and maintenance they require — are numbered, liberating garages, curbsides and parking lots.

In London this March, AECOM invited members of the public to the Queen Elizabeth Olympic Park to test out the first 'on-demand' connected and autonomous vehicle (CAV) using a mobile app in the UK, led by the Capri Consortium. The app allowed users to insert their start and end point from a preselected dropdown list, as well as the number of seats required and whether they needed special assistance services such as wheelchair access for the electric, driverless, connected vehicle they were summoning. The Capri trial is an excellent example of an ACES mobility system in action, and the small steps that are required now to inform policy that will make a big difference in the future.

In the context of the pandemic and social distancing personal safety needs, it is likely that demand for CAVs — which eliminate the need for personal contact and could incorporate automatic washing and disinfection functions — will increase.

NATURE-BASED SOLUTIONS

Nature-Based Solutions (NBS) are actions designed to work with and enhance natural habitats in order to take advantage of the ability of healthy natural and managed ecosystems to sequester carbon. In contrast with many engineered solutions, NBS have the potential to tackle both climate mitigation and adaptation challenges at relatively low-cost while delivering multiple additional benefits for people and nature.

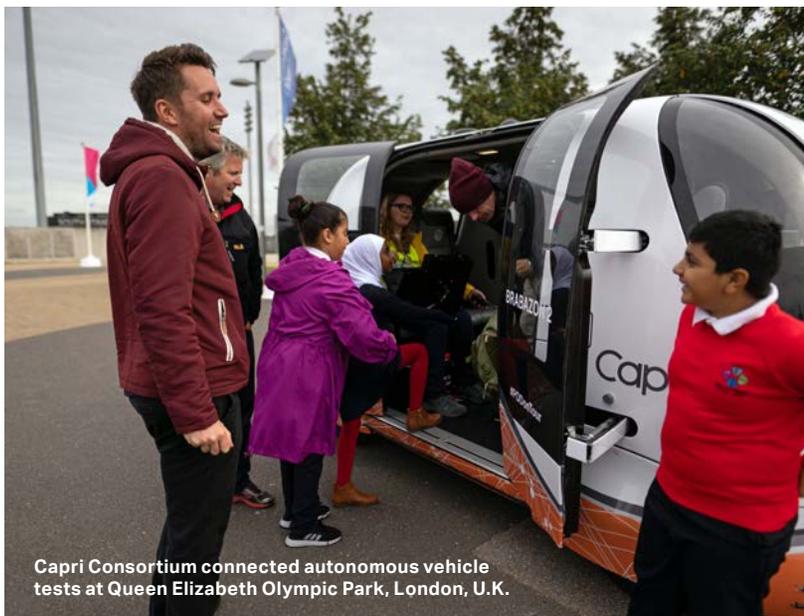
Well-designed policies and measures to protect and enhance forest resources, in particular, have a tree-mendous role to play in reaching the Paris carbon reduction goal. A recent scientific report³ named reforestation as one of the most effective carbon drawdown solutions to date, with the potential to erase as much as 100 years of carbon emissions. However, despite growing recognition of the potential of NBS, there is relatively little finance made available for their implementation. Efforts to restore, protect and enhance natural carbon 'sinks' are also often in competition with more lucrative sources of income from agricultural production and extraction and harvesting of natural resources.

To address these challenges, payments for ecosystem services (PES) have emerged as a possible means of financing investments in NBS. The basic idea behind PES is that those who benefit from the goods and services that nature provides (ecosystem services), reward those who adopt land management practices that support delivery of those services. PES may operate at a variety of scales.

In Ethiopia, AECOM explored the potential for setting up PES schemes in the highland forests in order to tackle issues of food and water security under a changing climate. Ethiopia wants to become a climate resilient middle-income country by 2025, with no net increase in greenhouse gas emissions. At the same time, the changing climate is putting pressure on Ethiopia's already fragile economy, impacting agriculture and creating issues of food security and desertification. Significant fluctuations in rainfall cause disruption to electricity distribution, 95 per cent of which is generated by hydropower, as well as water supplies. ➔

100 YEARS

Reforestation has the potential to erase as much as 100 years of carbon emissions.



Capri Consortium connected autonomous vehicle tests at Queen Elizabeth Olympic Park, London, U.K.



DEVELOPERS ARE UNDERSTANDABLY RELUCTANT TO LOOK BEYOND THEIR SITE AS THIS HAS THE POTENTIAL TO ADD COSTS, RISKS, DELAYS AND/OR CONTRACTUAL ISSUES TO THE PROJECT.

Through mapping and modelling the supply of and demand for ecosystem services, we identified the river basin areas and services that would be suited to the development of PES. First, we calculated the benefits the forest brings in terms of carbon storage and sequestration, shading for crops such as coffee, flood alleviation and prevention of sedimentation and siltation of major dams downstream. Then we looked at who might pay for these services, such as dam operators, coffee growers, and international climate markets to finance the interventions or land management actions required to protect the forest.

On the basis of the analysis, two sites were selected. Both would allow for carbon sequestration, qualifying for carbon credits in international carbon markets, whilst encouraging water quality regulation and the protection of the last remaining populations of wild-growing *Coffea arabica*, the leading commercial coffee species accounting for around 70 per cent of global production.

CROSSING BOUNDARIES

Developers are understandably reluctant to look beyond their site as this has the potential to add costs, risks, delays and/or contractual issues to the project. When it comes to energy consumption, however, physical and contractual boundaries are hampering our ability to deliver low energy, low carbon developments. Those willing to cross the red line boundary around the site stand to reap huge benefits in terms of sourcing 'secondary heat', such as heat recovery from sewerage systems, canals, rivers, and district heating schemes.

In Denver, the National Western Center is a legendary Colorado entertainment complex in the process of being re-imagined. The project has a long-term goal of becoming a net-zero energy campus and AECOM and partners Saunders and Enwave

were tasked with finding a solution, including long-term operation and maintenance.

A key part of the district renewable energy strategy is tapping heat from the Delgany sewer main to feed into an ambient campus wide piping distribution loop. The system will heat and cool six facilities, including the Stockyard Event Center, Livestock Center, and Equestrian Center by coupling the loop with high efficiency heat pumps. The sewer has twice the amount of energy needed to supply the entire campus and meets over 90 per cent of the heating load. Such are the benefits that the sewer — which needs to offload some of the thermal heat it carries for its own environmental compliance — is being re-routed through the site. By using this centralized district energy network, the energy use of the campus is reduced to the extent where the remaining demand could be generated with solar photo-voltaic (PV) panels on the building rooftops. →



National Western Center,
Denver, Colorado, U.S.

PRIORITIZING ACTIONS

2020 kickstarts a decade of environmental change, and cities and organisations are looking across the world for inspiration from projects such as those identified here. By 2030, it could be possible to eliminate carbon emissions — but only if we learn from the best the world has to offer.

Take Palo Alto, for example. This Silicon Valley city is a leader in renewable electricity and gas and has set itself a target of achieving 80 per cent greenhouse gas reductions by 2030, relative to 1990 levels — not an easy feat given its significant commuter traffic and congestion challenges. AECOM was recently selected to assist in an update of the City's Sustainability and Climate Action Plan that includes updating the city-wide emissions inventory with special attention on calculating the transport-related emissions and the benefits of emissions reductions, as well as engaging residents and businesses. Their support and participation will be crucial for the success of the plan.

The next step is making decisions, selecting projects such as those outlined here that will make our world a more liveable place. But where to start?

Bill Abolt, George Lunt, Petrina Rowcroft, Kenny Teeter, Calum Thompson, and Adriaan Window contributed to this article.



The climate action selection and prioritization (ASAP) tool is a key component within C40's Climate Action Planning programme, as it supports cities to deliver on their ambitious GHG emission reduction targets. The tool enables cities to prioritise their mitigation and adaptation actions and develop ambitious and equitable climate action plans in line with the objectives of the Paris Agreement. The C40 Climate Action Planning Programme provides a wide range of support such as training, workshops, peer-to-peer collaboration to C40 cities, a network composed of the world's megacities committed to addressing climate change.

—
**Michael Doust, Programme Director,
Measurement and Planning, C40**

To help guide the decision-making process, we've devised a tool for the C40 Cities Climate Leadership Group, which is leading 96 cities around the world through a climate action planning program designed to reach net zero by 2050. The C40 Climate Action Selection and Prioritisation Tool helps city staff and other users prioritise carbon reduction and climate adaptation actions to reduce emissions and increase resilience to climate hazards. Reflecting both best practices in climate action planning and the unique context and priorities of their city, there is no other climate action prioritization tool like this available.

Supported by over 1,500 lines of custom code and designed to be flexible to the needs, contexts and priorities of each city, the tool guides cities through each step in the action prioritization process. First, they enter data on the sources of emissions by sector, as well as the likelihood and impacts of various climate-related

hazards. Then they load in all the actions they are considering from programs to policies, physical projects and so on, rating their performance based on potential emissions reduction, vulnerability reduction, feasibility, and social, environmental and economic benefits. The results are displayed visually in a series of dashboards that guide decision-making. The tool is also designed to encourage stakeholder engagement.

In an ideal world, cities would be able to begin pursuing all actions necessary to achieve carbon neutrality and climate resilience simultaneously, but the reality is that all have limited resources and competing priorities. An action prioritisation process that reflects the priorities of the city is more likely to be successful and therefore help meet our net zero goals. This project is especially exciting because it will be used on five continents representing one twelfth of the world's population. [WI](#)



MOVING CITIES

LESSONS IN BUILDING FOR A BETTER FUTURE

Indonesia's planned new capital city must serve the needs of tomorrow's generations as well as today's. To be sustainable, promoters and sponsors can learn from the growing pains of other cities and give Kalimantan room to grow in unknown and perhaps surprising directions, writes AECOM's **Scott Dunn** and **Sylvester Wong**.

With a population of over 10 million,¹ Indonesia's capital city is bursting at the seams. Originally designed for a planned population of 800,000, Jakarta is becoming starved of resources such as drinking water, while crippling congestion impacts life and air quality. Weighed down by its fast-growing population, which has doubled in 50 years, the island capital is also sinking² — by an estimated 25 centimetres per year in some areas due to subsidence.

To address these concerns and capture the aspirations of a growing nation, the government is building an entirely new city to position Indonesia for growth and ultimately to take on a bigger leadership role in Asia and globally.

The new site in East Kalimantan, on the island of Borneo, was chosen for its resilient location, room for growth, and its more central location within Indonesia. The 400-square-kilometre plot of land comes with a \$US 33 billion (466 trillion rupiah) price tag.



THE GOVERNMENT IS BUILDING AN ENTIRELY NEW CITY TO POSITION INDONESIA FOR GROWTH

Making such an investment worthwhile, both economically and in sustaining natural resources, means ensuring future generations aren't saddled with expensive retrofitting. Predicting the future 50 years out is hard enough. Encouraging promoters and sponsors to think on these timescales — which exceed even the most forward-looking of government planning — is even a bigger challenge. ➔

To be sustainable, the megaprojects of the future must embrace the complex world they will inhabit, with enough built-in flexibility to adapt to the circumstances of tomorrow. So, what should Indonesia consider in its planning? And what lessons can be learned from other cities wrestling with growth, adapting to innovation and struggling to become more resilient to unforeseen stresses?



PLANNING A NEW CITY FROM SCRATCH IS NOT JUST ABOUT DOING A GOOD, LONG-TERM MASTERPLAN TO ENSURE THAT LAND IS EFFICIENTLY USED TO ACCOMMODATE SUSTAINABLE GROWTH. MORE IMPORTANTLY, IT IS ABOUT MAKING SURE THAT PEOPLE WILL LIVE, WORK AND PLAY COMFORTABLY WITH ENOUGH HOMES, JOBS, TRANSPORT, COMMUNITY AND RECREATIONAL SPACES THAT ARE PROVIDED IN A TIMELY MANNER WITH A GOOD DEVELOPMENT STRATEGY THAT INVOLVES THE PUBLIC AND PRIVATE SECTOR AND THE NEW COMMUNITY COLLABORATIVELY.

KHOO TENG CHYE (MR) EXECUTIVE DIRECTOR, CENTRE FOR LIVEABLE CITIES

To be future flexible, adaptability must be baked into the very beginning stages of the masterplan — and at every opportunity along the way.

Population flux — and how to plan for it

Indonesia is planning to develop 40,000 hectares of land for its new capital, housing an estimated 1.5 million residents, according to Planning Ministry estimates. These estimates could ultimately be influenced by many variables. For example, will current Jakarta residents retain their family homes, or will people from other regions and countries migrate to the new capital in search of better economic opportunities? If the population grows unexpectedly, is the infrastructure flexible enough to adapt and accommodate? Building with room to grow is essential. To ensure vibrancy, the new capital will need more than just homes and jobs — it will need a real core, culture and identity — and the infrastructure to support it. ➔

100%

Expected population increase of Riyadh over the next 10 years

RIYADH CITY

In Riyadh City in Saudi Arabia, AECOM is working under the assumption that the current population of more than 7 million will grow by 100% over the next ten years or an 8% increase per year. This sort of rapid growth requires flexibility of the highest order. A policy of transit-oriented development, which maximizes the housing, employment, and entertainment options within walking distance of public transit, is a good way to achieve that.

The city's spatial plans and its supporting infrastructure must be able to respond to situations

of global magnitude — from a worldwide financial crisis to the coronavirus pandemic. Over the coming decade, the Royal Commission is planning 424 initiatives totaling US\$55 billion ranging from greening to cultural and artistic aspects to urban revitalization, safety, wellbeing, airport expansion, heritage preservation and more. While Riyadh is already the largest urban economy in the region, the plan for the city aims for high quality growth that will turn it into a “mega-metropolis” while sustainably improving its liveability and mobility.



TRANSPORT HAS ALWAYS BEEN ONE OF THE MOST POWERFUL TOOLS AVAILABLE TO CITY OR REGIONAL PLANNERS. WELL DESIGNED AND DELIVERED TRANSPORT PROJECTS HAVE ALWAYS DRIVEN ECONOMIC GROWTH, GENERATED LAND VALUE AND SUPPORTED COMMUNITIES. BUT INCREASINGLY, TODAY, THE BEST TRANSPORT PROJECTS HAVE THIS KIND OF BROADER IMPACT BUILT IN AT THE EARLIEST STAGES, AS A CRUCIAL ELEMENT OF THEIR DNA.

—
MARK WILD, CEO, CROSSRAIL

Transportation needs are changing — and may evolve in unforeseen ways

Transportation infrastructure is fundamental to a city's economic, social and mental health. Investment today can serve a city's mobility needs for decades to come. But failing to account for flexibility could result in the sort of congestion and overcrowding seen in many of today's cities. Megaprojects like the one Indonesia is planning must consider incoming changes — from autonomous and connected vehicles, to aerial transport or hyperloop technology — that can influence planning and the infrastructure to support it.

The Government of Indonesia is ahead of the curve: it has announced that the new capital will be the first city in the world operating solely with autonomous and electric vehicles. Many of these are likely to be provided by Mobility as a Service (MaaS) providers combining public and private transport options which users can access on demand. The movement of goods, which typically makes up to 30 per cent of trips, can be consolidated with regional distribution centres and last kilometre connections with drone deliveries. If such services are as efficient as they claim to be, the days of individual car ownership and congested roads could be drawing to an end. Liberated parking lots and kerbside space could be put to better use. ➔

BUT WHAT ABOUT THOSE CHANGES WE CAN'T FORESEE?

One approach is to protect designated physical right-of-ways with strong governance and guidelines — as seen with the Bloor Street Viaduct in Toronto, Canada. This major bridge over the Don River valley was built 100 years ago, long before anyone thought about a subway. Yet project designers built in a provision for a rail crossing on a level below the bridge deck. Half a century later, this became the future alignment of the Bloor-Danforth Subway (Line 2). Thanks to that, the subway was built at a fraction of the cost — and with less disruption — than if a separate crossing had been required.

Another approach, from Europe's largest construction project, is to ensure the public transportation is much more than just getting people

from point to point. With more than 100 kilometres of rail spanning London from east to west, Crossrail aspires to completely transform the urban realm around its train stations through a multi-pronged approach taking into consideration everything from historical preservation to improved traffic flow, flood protection and security measures to enhanced public open space.

AECOM's work collaboratively designing and advising on the public realm and infrastructure for Crossrail's Farringdon and Paddington stations showcases the opportunity to create a pedestrian friendly urban realm that improves safety, utility, capacity and the overall patron experience. Plans feature public art displays, street furniture and landscaping that can easily be adapted to keep pace with the changing personality of the surrounding neighbourhoods.

Flooding in
Indonesia

Preparing for unforeseen shocks

Beyond the more predictable considerations of population growth and transportation, are other challenging factors. Climate change, for example, is becoming increasingly erratic, and global pandemics are clearly no longer a distant possibility. To meet these challenges, our infrastructure needs to become more resilient. In the past, we've relied as an industry on historical data to forecast future events, some of it of poor quality. This is no longer sufficient. Designers must broaden their consideration of weather patterns to include the predictable annual events as well as the more unpredictable 'once in a century' type occurrences.

As in much of Southeast Asia, Kalimantan often experiences severe flooding during the inevitable annual monsoon season — and built up spaces will only exacerbate this. In the past, making the case for funding such 'unforeseens' has proved difficult. Some have argued that money spent protecting infrastructure against things which might never happen could be better spent on more concrete needs. Once in one hundred-year incidents, such as Hurricane Sandy and even the coronavirus pandemic, have changed that thinking. Today, resilience should be built into megaproject planning right from the masterplan.

Whereas Kalimantan has the luxury to plan, older cities require retrofitting. In developing New York's master plan for Lower Manhattan coastal resilience, AECOM had to consider a diverse set of current and future public needs spanning a number of adjacent spaces as part of our design efforts.

One of those projects is South Battery Park. This unique stretch of coastline involves rebuilding Wagner Park with a hidden, passive line of protection that enhances the public space and potential for economic development. The project aims to protect the neighbourhood and the people who live in it by reducing flood risk due to coastal storms and sea-level rise. At the same time, the goal is also to improve waterfront access so the community benefits even when there is no flooding or other risk.*

As the Lower Manhattan resilience work spans 10 continuous miles (16.09 kilometres) of coastline, there are several stakeholders involved. Each of the distinct sections of waterfront is planned and funded differently, and discussions are ongoing to explore new sources of cross-sector funding and financing,³ as well as ways to capture future value generated by resilience projects to help bridge the funding gap. These lessons are relevant to planning for Kalimantan.

Making the financial case for Kalimantan

The government plans to fund around 19 per cent of the total US\$33 billion cost, with the balance coming from other sources. At the same time, the Indonesian government has announced its intent for a monumental \$412 billion nationwide infrastructure spending plan spread across 17,000 islands. To date, committed funds remain elusive for both projects, and a significant portion of funds will likely have to come from private sector finance, institutional funds and even the growing global green capital market.

Private equity finance and institutional fund participation in large-scale infrastructure are increasingly popular tools, going hand-in-hand with land development opportunities for local and foreign investors that would otherwise be difficult to secure. This may be the next evolution of the infrastructure-as-a-service model, moving away from traditional subsidy-heavy financial structures.

The rail-plus-property model of Hong Kong's MTR is a prime early example, with over half of the transit system's revenues generated through property development and management. In this post-pandemic era where recurring income from infrastructure tariffs and fares are vulnerable, diversification of cash flows can keep essential infrastructure viable. This goes beyond the tax-increment value capture that is already popular in the U.S.; the primary revenue stream comes from integrated commercial real estate rather than the infrastructure itself.

Early hesitation to cede national lands to foreign owners is being addressed through creative land lease frameworks and asset divisions that keep lands in the hands of nationals. This has enabled the likes of Japanese tech conglomerate Softbank and the Emirati Sovereign Fund to explore partnerships to develop portions of the capital in exchange for underwriting support. ➔

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TODAY,
RESILIENCE
SHOULD BE
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MEGAPROJECT
PLANNING
RIGHT FROM THE
MASTERPLAN.”

\$33bn

Cost of the land for
Indonesia's new
capital city

\$412bn

Cost of Indonesia's
nationwide
infrastructure
spending plan

But international investors are increasingly demanding more than financial returns and guarantees. Resilience targets and environmental, social and governance (ESG) targets may include pandemic readiness, digital readiness, a diverse portfolio of economic engines, measures of equity and inclusivity as well as preservation of authenticity. These sorts of measurements can serve as a framework for other countries or investors with similar goals wanting to participate or invest in the Indonesian government, helping them realize their dream of moving the capital city.

In neighbouring Philippines, the nation's own backup centre for government is emerging at the US\$23 billion New Clark City. The 9,000ha master plan by AECOM is now the focus of the nation's first government green development bond, with hopes of attracting ESG-minded private investment to realize its original vision for a sustainable and resilient city of one million people.

Managing Complexity

From the constrained streets of London to the sunken Egyptian city of Heracleion, history is littered with examples of megaprojects that have failed the sustainability test. The promoters and sponsors of sustainable infrastructure must be flexible and persuaded to plan and finance for a future they can't yet imagine — and which they might never see.

It would, however, be naive to expect the financiers of Indonesia's new capital to invest in an unspecified future. A more compelling argument must be developed around making long-term sustainability deliverable within the parameters that constrain the promoter (cost, time, space, technology, resources, knowledge, etc.). Ideas around passive provisions, elimination of pinch points, adaptability, market trends, demand and other topics will be required. Behind it all is the need for the managers of megaprojects not to limit themselves to what they know now, but to be flexible and adaptable to ensure that their projects thrive for generations to come. [WU](#)

This article builds on The era of sustainability-enabled megaprojects: lessons in building to deliver for an unknown, better future by AECOM's Jim Manning and Mariella Tsopela. Their submission was voted best sustainability paper at the MeRIT Megaprojects Research Interdisciplinary Team conference in Milan, 2019.

Izlem Boylu, Alan Gibbs, James Kirkpatrick, Mike Pauley, Sacha Schwarzkopf and Joel Sonkin contributed to this article.



THE PROMOTERS AND SPONSORS OF SUSTAINABLE INFRASTRUCTURE MUST BE FLEXIBLE AND PERSUADED TO PLAN AND FINANCE FOR A FUTURE THEY CAN'T YET IMAGINE – AND WHICH THEY MIGHT NEVER SEE.

Jakarta, Indonesia's existing capital city





CULTIVATING INNOVATION IN RISK-AVERSE INDUSTRIES

Given the budgets and timescales involved in the delivery of big infrastructure projects, it's not surprising the industry has traditionally prioritized operational excellence over innovation. There's a growing realization, however, that innovation is needed to stay competitive, say AECOM's **Orla Pease** and **Colette Munro**.

Urban infrastructure is coming under pressure like never before. The United Nations¹ estimates two-thirds of the world's population will live in urban areas by 2050. Even if this projection is affected by coronavirus still we are likely to see increasing demand for water, sanitation and transport services — not to mention places to live and work. At the same time, climate change is making demand volatile at a time when margins are being squeezed. Business as usual is no longer an option.

Transforming risk-averse industries such as water, transport and commercial real-estate is no easy task however. Moving from a culture that minimizes risk to one that rewards risk-taking is a big ask. In an industry where even small errors can be very costly, it's natural to be cautious about deviating from old ways of doing things, particularly for those who'll be held responsible if things go wrong.

In the following section, we take an in-depth look at three AECOM innovations developed to help our clients do business better and highlight some of the lessons we learned along the way. ➔



TRANSFORMING RISK-AVERSE INDUSTRIES SUCH AS WATER, TRANSPORT AND COMMERCIAL REAL-ESTATE IS NO EASY TASK

WATER

To date, the industry's track record on innovation has been mixed. It has invested large sums in research and development, but has sometimes failed to turn that knowledge into value.

The multitude of challenges facing the industry means that is changing. Here we look at an example of innovation driven by environmental need.

Algae removal technology

In summer, slicks of mossy green sludge coat the surface of many of our lakes, rivers and seas. Lapping up the sun's energy, these algae blooms can multiply rapidly, feeding on nitrogen and phosphorus in the water. When they die, they can release toxins, posing a threat to public health. As well as raising treatment costs for drinking water, such harmful algae blooms (HABS) can have severe impacts on the health of humans, animals, aquatic ecosystems and local economies. In

Results from the algae harvesting technology platform

95%

Phosphorous removed

82%

Nitrogen removed

97%

Microcystin toxin removed

the United States alone, HABS cost \$1 billion a year in damages. HABS are becoming more frequent, severe and lasting longer due to a combination of growing populations and climate change, which is seeing floods and hurricanes sweep agricultural nutrients from fertilizers and runoff into lakes and rivers.

In July 2016, Florida Gov. Rick Scott declared a state of emergency when nutrient-rich water from Lake Okeechobee was discharged seaward to both coastlines, resulting in HABS formation and the closure of the beaches. AECOM's Dan Levy, a geologist and long-time Floridian, realized this crisis was a new type of situation. Despite decades of research, a long-term solution was lacking. The issue, as with most HABS, was that no single entity was responsible, making it difficult to pinpoint how clean-up efforts would be funded.

Levy's first step was to appraise current technologies, finding them limited and involving unwanted

environmental side-effects. One of the most widely used is a copper sulfate algicide, a poison that kills the algae and releases phosphorus, one of the key nutrients that fuels algae growth. When the sun returns, so does the algae — only stronger. Levy set about looking for ways to physically remove the key nutrients that fuel algae growth from the water without harming the environment. He established a team of environmental experts who began exploring ways to use dissolved air flotation. Pilot tests conducted in Florida showed it was effective and could be scaled.

Two years later, the beaches were again closed for 2½ months at the height of the holiday season. Realizing the devastating effect on the Florida economy, Governor Scott declared a state of emergency which allowed the two hardest hit areas, Lee and Martin Counties, to use AECOM's algae harvesting technology.

At the same time, America's Water Infrastructure Act was prompting the US Congress to free up funds to support HABS research and mitigation strategies. The US Army Engineering Research and Development Center (ERDC) enlisted support from AECOM for its HABITATS research. Key elements of HABITATS were pilot tested on Lake Okeechobee last summer and proved effective. Additional field testing to transform the recovered algae into biofuel is planned this year in Florida and New York.

In the past three years, AECOM scientists have shown that the algae harvesting technology platform has been effective in removing over 95 per cent of phosphorus, 82 per cent of nitrogen, and 97 per cent of the microcystin toxin. The process provides an algae biomass feedstock that can be transformed into biofuel and commercial biofoam products to support a green economy. To prevent future outbreaks of harmful algae blooms, the system can be used to reduce the nutrient loading into our nation's waterways. ➔

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ONE OF THE MOST WIDELY USED METHODS TO REMOVE ALGAE IS A COPPER SULFATE ALGICIDE, A POISON THAT KILLS THE ALGAE AND RELEASES PHOSPHORUS, ONE OF THE KEY NUTRIENTS THAT FUELS ALGAE GROWTH. WHEN THE SUN RETURNS, SO DOES THE ALGAE — ONLY STRONGER.

Lake Okeechobee, Florida, U.S.

TRANSPORTATION



FOR ENGINEERS DEALING WITH THE COMPLEXITY OF SUCH PROJECTS, NEW TECHNOLOGIES ARE EMERGING THAT VASTLY REDUCE THE TIME NEEDED TO UPDATE ALL PARTS OF THE DESIGN WHEN CHANGES ARE MADE.

Large-scale transport infrastructure projects are by nature complex and uncertain. The risks of failure are high financially, environmentally, technically, managerially, politically and legally. It's no wonder that the promoters and financiers of such projects tend to be wary of innovation.

At the same time, to be sustainable, these transport projects need to understand the needs of their future evolution. This requires visionary leadership, persuasive arguments, innovative thinking and the ability to launch and learn.

Re-imagining tunnels

Constructing a tunnel is one of the most complex tasks in civil engineering. Not only does the tunnel need to be excavated, but the attributes of the rock or soil encasing the tunnel needs to be considered, as well as how each part of the structure will be impacted by the weight of the people and vehicles moving through it. In short, it's a complex process that is difficult to picture.

Digital technologies are changing all of that. 3D modeling and virtual reality technologies make the tunnel easier to visualize, particularly for those who aren't trained to do so, such as project sponsors or the general public. For engineers dealing with the complexity of such projects, new technologies are emerging that vastly reduce the time needed to update all parts of the design when changes are made.

In Auckland, New Zealand, AECOM was appointed as part of the Link

Alliance Consortium² to deliver an ambitious project to double the city's rail capacity via a new two-way through-station. The City Rail Link (CRL) project is a 3.45 kilometer twin-tunnel underground rail link up to 42 meters below the city center and is due to open in 2024.

As part of its solution, AECOM adopted parametric modeling, or the use of algorithms to automatically generate digital models. Over 200 designers and engineers working in different locations and across eight teams are involved in the project. Coordinating them — and ensuring everyone is working on the latest design — was a huge logistical challenge.

AECOM's digital engineering teams knew the team needed to be able to live-share, interrogate and review the current design simultaneously. To do this, they set about creating a common data environment encompassing 50 different models that could be accessed via a single online location, without the need for additional software or hardware.

Through a combination of traditional BIM modelling processes and parametric design, they enabled the model to be automatically updated by internal logic arguments rather than being manually manipulated by engineers or modelers. This combination has reduced the modelling time for the design of the CRL tunnels from weeks to hours.

It was the first-time parametric design has ever been used in tunnel construction. The team is now applying these techniques to other parts of the CRL project. ➔



THE RISKS OF FAILURE ARE HIGH FINANCIALLY, ENVIRONMENTALLY, TECHNICALLY, MANAGERIALLY, POLITICALLY AND LEGALLY. IT'S NO WONDER THAT THE PROMOTERS AND FINANCIERS OF SUCH PROJECTS TEND TO BE WARAY OF INNOVATION.

CONSTRUCTION

Although the construction industry was seen as a late adopter of digital technologies, it is embracing cloud-based tools at speed. This is because the potential of 5D Building Information Modelling (BIM), digital collaboration and mobility, the Internet of Things and advanced data analytics have huge potential in streamlining processes, saving time and money. ³

Better coordination

Renowned for delivering some of the world's most iconic buildings — from One World Trade Center, the tallest tower in the Western Hemisphere, to CityCenter, the largest privately funded development in U.S. history in the heart of the Las Vegas Strip — AECOM Tishman has built more than 1.5 billion square feet over the past century. They've been able to leverage their experience to innovate over the years.

As the capabilities of 3D modeling software advanced, the AECOM Tishman team began looking at how this technology could be used to reduce frequent bottlenecks in planning the mechanical, electrical and plumbing (MEP) infrastructure of tall buildings. MEP infrastructure is like the central nervous system of a building. To be efficient, all systems must run in synergy — requiring a lot of coordination during construction.

Historically, one of the most critical phases occurs after trade contracts are awarded. This is called the shop drawing development phase, typically led by our construction management team in conjunction with the design team and the detailers, drafting people from each of the relevant trade contractors. Together, this team works collaboratively to resolve conflicts

and develop a set of fully coordinated shop drawings that serve as a roadmap for efficient construction. The process is time consuming, requiring coordination and approvals from a variety of stakeholders. In short, it frequently becomes a bottleneck.

AECOM Tishman realized this process could be dramatically improved if the coordination occurred before the trade contracts were awarded, so that the cost and schedule benefits of this coordination effort could be incorporated into the bid documents and then realized during the procurement process. Using 3D modeling software and other software platforms that enhance collaboration and enable faster sign-offs, we created a proprietary process called OneDesign that has been proven to save our clients time and money.

Used on several recent tower projects in Manhattan, we've seen OneDesign reduce the range of multi-million dollar trade contractor bids by more than 50 per cent, which provides increased price certainty and helps clients lock in more favorable financing terms sooner. The OneDesign process also leads to construction documents that are clearly coordinated and buildable, which presages a lack of field clashes during construction.

As with many great inventions, the solution looks simple in hindsight. The complexity lies in its execution, which is only possible thanks to BIM technology. A number of sub-processes must work concurrently to preserve critical design-bid-build roles, responsibilities and liabilities. OneDesign requires the skillful use of technology and the administration of a carefully organized coordination process that cannot be easily duplicated.

Jeff Atherton, Dan Levy, Chrysostomos Loizou, David Philp, Ian Small, and Ashley Weyell contributed to this article.



INVESTING IN PEOPLE

To prevent caution from stifling innovation, AECOM's experience is that ideas, and the people who put them forward, need to be protected until they are robust enough to stand on their own.

As innovators, we're always thinking about how to improve what we're doing. To encourage like-minded colleagues, we launched Mindblazer, a tool designed to encourage ideas that support technical excellence, innovation and collaboration on AECOM projects. Every three months we put out a call for ideas — with a two-week window for submission for anyone within AECOM. We focus on projects that address a burning need and/or have a transformative effect, versus routine proposals.

Our employees are our biggest asset and our mission is to provide them with a supportive environment that allows and encourages innovative ideas. We believe the process of thinking creatively has wider benefits, but not all ideas advance to implementation. As these three examples show, innovation is most effective when carried by the momentum of a burning need. ^{WL}

WITHOUT LIMITS

Imagine it. Delivered.

About AECOM

AECOM is the world's premier infrastructure firm, delivering professional services throughout the project lifecycle — from planning, design and engineering to consulting and construction management. We partner with our clients in the public and private sectors to solve their most complex challenges and build legacies for generations to come. On projects spanning transportation, buildings, water, governments, energy and the environment, our teams are driven by a common purpose to deliver a better world. AECOM is a *Fortune 500* firm with revenue of approximately \$20.2 billion during fiscal year 2019. See how we deliver what others can only imagine at aecom.com and [@AECOM](https://twitter.com/AECOM).