

**WITHOUT  
LIMITS**

**AECOM**

# THE FUTURE OF INFRASTRUCTURE

Expert opinions on the challenges  
and opportunities ahead

**NORTH AMERICA EDITION**

## **FUNDING AND FINANCING**

Finding solutions in a resource-  
constrained environment

---

## **FASTER, SMARTER, BETTER**

New approaches to delivering  
future infrastructure

---

## **SKILLS 2030**

How to build the future workforce

---

## **RESILIENCE**

Future proofing and mitigating  
physical and digital attacks

---

## **INNOVATION**

Take a trip to a day in the life of 2030



**2018**

For the full global report, visit:  
[infrastructure.aecom.com](http://infrastructure.aecom.com)

## FOREWORD

# THE FUTURE OF INFRASTRUCTURE

Welcome to this first Future of Infrastructure report from AECOM.

As a company focused on building a better world, we are passionate about our work in advancing infrastructure that improves quality of life and prepares us to meet the challenges ahead. Increasingly, we see networks and systems around the world coming under considerable strain. At the same time, as the physical and digital worlds converge, we are also witnessing amazing innovations and new ideas just around the corner. These are testing and exciting times.

As we speak with friends, colleagues and clients in the industry, we hear expressions of worry and optimism, caution and exuberance about what's ahead. To get an accurate picture of the times and how people think infrastructure may change in the future — or how the future may change infrastructure — AECOM has undertaken this research.

For this US and Canada edition of the report we surveyed more than 300 civil infrastructure decision makers, all of whom work on infrastructure projects valued at more than US\$100 million. To set this in context, this research formed part of the global survey of more than 500 industry professionals. In addition, we also conducted detailed interviews with more than a dozen key figures in our industry. The aim has been to better understand the problems, priorities and potential in delivering major infrastructure projects.

For example, 65 percent of North American respondents feel that the industry is not evolving fast enough to meet our changing needs; more than one-third identify a lack of



public funding as key to holding up new projects; and more than eight in 10 believe this is a pivotal time for civil infrastructure.

In addition to hearing from our survey respondents, we have included a number of articles in this report to address many of the key issues raised and to help inform new discussions that can unlock workable, sustainable solutions.

Amid the impacts posed by urbanization, climate change and the dizzying pace of technological advances, merely narrowing the infrastructure gap can no longer be a baseline goal for our industry, our clients and governments. What's needed is a giant leap forward — focusing the smartest minds, training and deploying more skilled workers, and leveraging new digital tools to deliver a better future through infrastructure.

Success lies in people working together with a shared vision in our industry and beyond. The potential offered by high-quality infrastructure is transformative, and getting it right is everyone's business. 

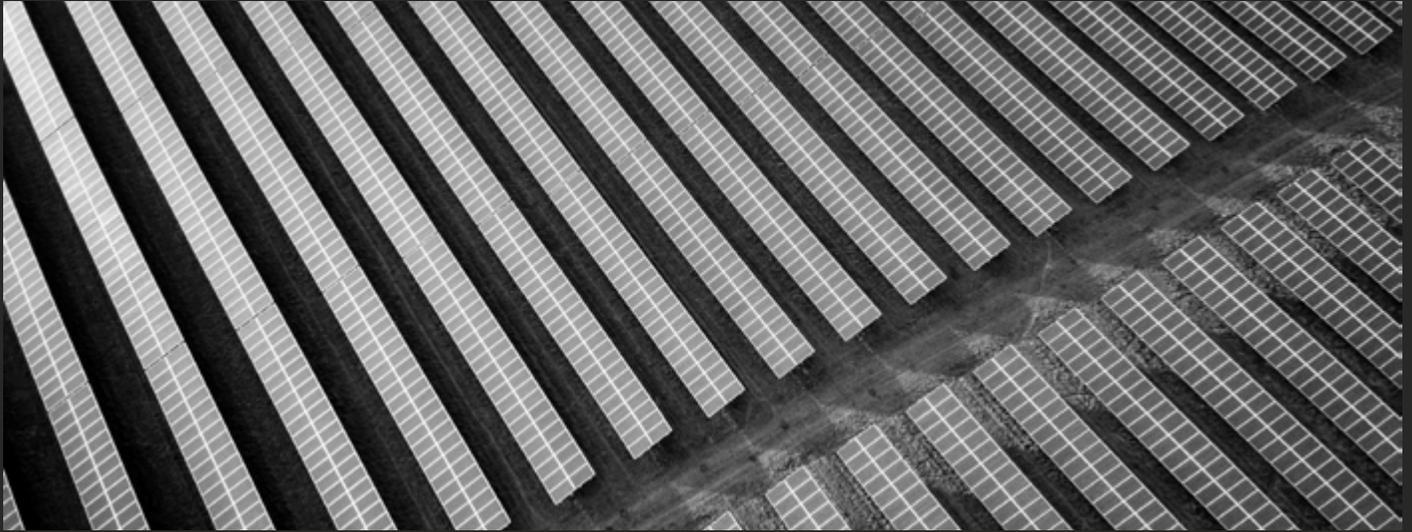
**Michael S. Burke**  
Chairman and Chief Executive Officer

## Are you ready for the future of infrastructure?

Is your organization ready for the challenges and opportunities ahead?

Use our five-minute tool to find out how you compare with infrastructure organizations around the world.

Discover more  
[infrastructure.aecom.com/benchmarking](https://infrastructure.aecom.com/benchmarking)



6

**Executive Summary and Key Findings**

A snapshot of key report highlights about the perceived value of infrastructure, the appetite for change, funding challenges and the desire for innovation to help make the big leap forward.

8

**Part One**  
Growth, Progress and Change: Why the Industry Needs to Speak Up

While there is broad agreement that infrastructure will play an important role in shaping our future, much has to change to meet growing demands for services.

20

**Part Two**  
A Pivotal Moment for Infrastructure

Existing infrastructure is under strain as demand far outstrips supply. With future networks and systems slow to be delivered, it is time to embrace new tools and approaches, and develop a workforce for the future.

34

**Part Three**  
Building the Resilient Future

With the increasing number of cyberattacks and extreme weather events, a focus on resilience is recognized as a route to supporting an improved quality of life for all.

46

**About this Research and Acknowledgments**

18

**Insights**  
The Infrastructure Gap: Financing and Funding the Future

With increasing urgency to resolve the financing and funding of infrastructure projects, Michael S. Burke, Chairman and Chief Executive Officer at AECOM, and co-author and Specialist Consultant, Clive Lipshitz outline several approaches that, taken together, can help reduce the infrastructure gap.

30

**Insights**  
Delivering Future Infrastructure: Faster, Smarter and Better

As the industry seeks to bridge the global infrastructure gap, the delivery of many critical assets is still being delayed. The combination of technology and alternative delivery can be truly powerful in solving this productivity issue, write industry-leading project delivery experts Richard Robinson and Matt Forbes.

32

**Insights**  
Skills 2030: Securing the Talent to Build our Future Infrastructure

Technologies are transforming our lives and our world ... and that includes every type of infrastructure you can imagine. In response, Roma Agrawal and Susan Dumond propose a skills manifesto for securing the engineering talent to build our future infrastructure.

41

**Insights**  
Resilience: In a Shifting World

Future proofing civil infrastructure projects is one of the biggest challenges facing the industry, write infrastructure resilience experts Ronald Hahn and Josh Sawislak.

44

**Insights**  
Stranger Than Fiction: A Day in the Life of Future Infrastructure

From the Jetsons to Futurama, and Star Trek to Blade Runner, we've all seen imagined futures. Veronica Siranosian and Andrew Bui look at some of the biggest emerging infrastructure trends.

# INFRASTRUCTURE IS EVERYONE'S BUSINESS

Resilient and sustainable infrastructure is critical to economic growth and social progress. Looking at the challenges and opportunities ahead, the full global Future of Infrastructure report harnesses the views of more than 500 industry decision makers worldwide, all of whom work on projects of +US\$100 million.



GLOBAL 82%

NORTH AMERICA 83%



82% believe that investment in infrastructure is essential for national prosperity

## FUNDING CLOSING THE INFRASTRUCTURE FUNDING GAP



**INNOVATIVE MODELS**  
90% believe innovative funding models are effective at bridging the funding gap.



**UNPREPARED FOR THE CHALLENGE**  
However, only 24% believe the industry is fully prepared for the challenge of attracting private investment.

## RESILIENCE A COUNTDOWN TO CATASTROPHE?



**CYBERATTACK OR CITYWIDE TRANSPORT DISRUPTION**  
71% say a major cyberattack or citywide transport disruption is probable in the near future.



## ACCELERATED DELIVERY DELIVERING FASTER, SMARTER, BETTER



**TRADITIONAL APPROACHES**  
71% believe traditional approaches do not fit large, complex projects.



**SEAMLESS INTEGRATION**  
72% feel that seamless integration is essential for faster, smarter, and better delivery.

Changes in legislation and innovative funding models are needed to remove obstacles and allow the public sector to better access private sector financing.

Discover more:  
**THE INFRASTRUCTURE GAP: FINANCING AND FUNDING THE FUTURE, PAGE 18**

Future proofing and protection to guard against cyber and physical attack are essential for all existing networks and systems.

Discover more:  
**RESILIENCE: IN A SHIFTING WORLD, PAGE 41**

## R E S P O N D I N G T O

As we enter the Fourth Industrial Revolution, the world of infrastructure project design and delivery is changing. Digital expertise is the key to a successful future.

Discover more:  
**DELIVERING FUTURE INFRASTRUCTURE FASTER, SMARTER AND BETTER, PAGE 28**



Investment is crucial to society.

**16%**

Only 16% believe that the infrastructure industry is evolving fast enough to meet society's changing needs.

**DELIVERY**

**TRADITIONAL APPROACHES**  
 Believe that many of the old, tried-and-tested methods to project management are not meeting the demands of today's complex programs.

**SEAMLESS INTEGRATION**  
 Believe that most projects are a long way from achieving seamless integration of providers.

**SKILLS INNOVATORS WANTED**

**21%** **SOURCING THE RIGHT SKILLS**  
 21% feel the industry is fully prepared to source the right skills to meet future industry challenges.



**INNOVATION THE INFRASTRUCTURE INNOVATION DEFICIT**

**3 IN 4** **OUT OF SYNC**  
 Three-quarters believe that alternative technical concepts from the private sector provide the best opportunity to develop innovative infrastructure solutions.



**THE CHALLENGES**

Industrial Revolution, we need to rethink every. Connected seamless approach.

For the workforce of the future, the industry needs an image update — as a place that is diverse and inclusive, valuing wellbeing, innovation and career progression.

Innovation in projects and project delivery must go hand in hand with innovation in the workplace to guarantee future success in the industry.

**INFRASTRUCTURE: GETTING IT BETTER, PAGE 30**

**Discover more: SKILLS 2030: SECURING THE TALENT TO BUILD OUR FUTURE INFRASTRUCTURE, PAGE 32**

**Discover more: STRANGER THAN FICTION: A DAY IN THE LIFE OF FUTURE INFRASTRUCTURE PAGE 44**

# Executive Summary — the Global Picture

---

AECOM's new research comes at a time of unprecedented complexity and transformation, complicated by rapid urbanization, demographic change and the maturing of our digital age.

---

## **Growth, progress and change: Why the industry needs to speak up**

We find an industry that is unified in its belief that infrastructure will play an important role in shaping the society of the future. Over 80 percent of the more than 500 professionals surveyed agree that national prosperity depends on civil infrastructure.

Respondents also recognize the harm that will be caused if the industry cannot deliver on its promises. Congested roads, unreliable and overcrowded rail services, power outages, drought, flooding, and cyberattacks cost individuals, communities and industries billions of dollars every year.

To encourage greater investment, the infrastructure industry needs to do more to promote the positive contribution that it makes to people's lives. While government funding remains constrained, it is clear that work, including innovative funding models, is necessary to aid the flow of private money into public projects. More than one-third of global survey respondents cite funding shortages as the number one constraint in getting new projects off the ground.

## **A pivotal moment for infrastructure**

Eight in 10 of the survey respondents agree that this is a pivotal time for civil infrastructure.

The industry must play a vital economic and societal role in supporting technological progress and shaping the communities of tomorrow. Our respondents share a willingness to embrace challenges and to develop fresh approaches to longstanding problems — and this must be done sooner rather than later.

Poor project and program management is also a major concern. A large majority of respondents feel that many tried-and-tested approaches fail to meet the requirements of today's increasingly vast and complex civil infrastructure programs. A logical inference is that the industry needs to run major infrastructure projects very differently.

In addition to developing new ways of running projects, workforce skills are also clearly a concern. One-quarter of the survey respondents cite skills and talent shortages as obstacles to progress, and about one-fifth say that difficulties sourcing the right talent cause major delays.

## 80%

Over 80 percent of the more than 500 global professionals surveyed agree that national prosperity depends on civil infrastructure.

## **Building the resilient future**

It is easy to get excited about the future. When considering transportation, for example, we all like to imagine a world of autonomous cars, digital railways that anticipate and help improve reliability, and Hyperloop links to usher in a whole new way of traveling.

Digital technologies and the Fourth Industrial Revolution are providing many of the tools we use; however, in today's digital world, protection against cyberattacks is one of the most critical aspects of resilience. When asked about the likelihood of certain events in the next five years, survey respondents offer a sobering assessment. About one in three believes that catastrophic events — a major ransomware attack or city-wide transport disruption — are almost certain in the near future.

As a result, we need to upgrade existing networks and systems, as well as create new ones; embrace innovation in the ways we work and the infrastructure we rely on; and ensure that the infrastructure we create is resilient and future proofed to help withstand the shocks and stresses to come.

Change is coming fast. We must leap ahead to build a better world and make sure no one is left behind.

# Key Findings for North America

## 1/

Future infrastructure will continue to play an important economic role, but is undervalued outside the industry



More than four-fifths of respondents say that adequate investment in infrastructure projects is crucial to national prosperity.



But they sense that this feeling isn't reciprocated on a wider level. Eight in 10 believe the sector's positive economic and social contributions are undervalued.

## 2/

Industry professionals are highly engaged, but they are also frustrated



Just under two-thirds feel that the industry is not evolving fast enough to meet society's changing needs.



Their responses reveal that more than one-third of major projects run into difficulties, causing serious delays. And only a slim majority of professionals believe they are good at responding to change, streamlining activities and adopting innovative delivery models.

## 3/

Infrastructure funding shortages are hampering progress



Some 36 percent identify a lack of public funding as the key reason why civil infrastructure is failing to keep pace with society's needs.



In many cases, this is a result of poor allocation of taxpayers' money. Nearly one-quarter of survey participants cite poor infrastructure project choices at the national government level as the reason why many new projects never come to fruition.

## 4/

The industry is experiencing an innovation deficit



Almost seven in 10 industry professionals say that tried-and-tested approaches are out of sync with the complexities they face. They need new technologies; eight in 10 say alternative technical concepts from private contractors provide a great opportunity for innovative solutions.

Innovation is seen as the third most important skill for the future of infrastructure, but it is also the least available within the professional workforce. The workforce must be upskilled.





## Part One

---

# Growth, Progress and Change: Why the Industry Needs to Speak Up

### In brief

---

**01/** More than eight in 10 industry professionals agree that national prosperity depends on civil infrastructure

**02/** It is widely acknowledged that the industry is not moving fast enough to meet growing demands

**03/** We all need to be more vocal about infrastructure's positive benefits

**04/** There are funding challenges, but they can be overcome with innovative approaches and novel solutions

---

AECOM's new research comes at a time of unprecedented complexity and transformation, complicated by rapid urbanization, demographic change, and the maturing of our digital age.

---

In turn, we find an industry that is unified in its belief that infrastructure will play an important role in shaping the society of the future. More than eight in 10 of the over 300 North American professionals surveyed agree that national prosperity depends on civil infrastructure. Strong transport connections enable urban regeneration, new job creation, and the delivery of goods and services.

Respondents also recognize the harm that will be caused if the industry cannot deliver on its promises. Congested roads, unreliable and overcrowded rail services, power outages, drought, flooding and cyberattacks cost individuals, communities and industries billions of dollars every year. Each one of us has experienced the frustrations and inconvenience of inadequate infrastructure.

### Slow progress

Respondents say they have faith in the ability of government departments to select the right projects for their communities, but our findings suggest that the industry is not moving fast enough to meet requirements.

Often, this is because the importance of civil infrastructure is overlooked. A concern voiced by many respondents was that infrastructure is taken for granted by the general public. Eight in 10 feel that the industry's positive economic and social contributions go unnoticed.

It is little coincidence that, in many advanced economies, infrastructure investment takes a back seat to areas such as health and education. Poor public relations may be to blame. Greater media coverage has created a level of awareness and understanding around other public services that infrastructure sorely lacks.

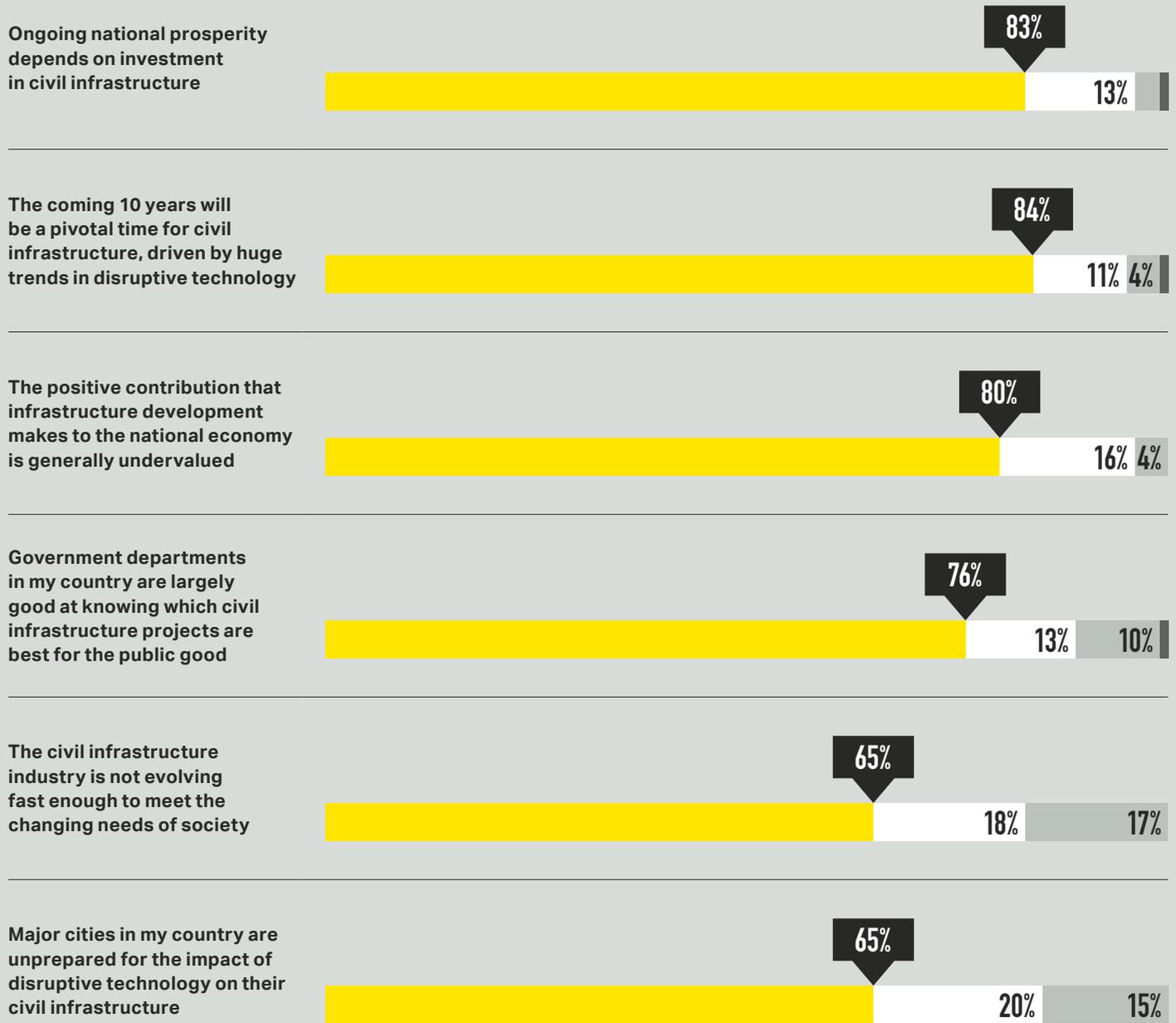
“

A major argument for our 2016 ballot measure was that congestion in this region almost doubled in the previous five years alone. We're projecting an influx of nearly a million more people by 2040. Local government expects projects to move along quickly, because that's what voters are demanding.”

— Peter Rogoff, Chief Executive Officer, Sound Transit

Figure 1/

## Proportions of respondents in North America that agree with key statements about the industry



Agree Neither agree nor disagree Disagree Don't know



There is a lack of understanding of how infrastructure is provided and maintained at a government level. People just think, “Why aren’t things changing?””

—  
**Therese McMillan, Chief Planning Officer, Los Angeles County Metropolitan Transportation Authority (LA Metro)**

Government failure to provide clarity increases confusion around how major projects are selected and funded.

Infrastructure projects are largely publicly funded and owned, but can attract partnerships with the private sector that generate greater innovation, accountability, and long-term performance. The recent engagement of influential business figures — notably Elon Musk and Richard Branson — highlights the potential for attracting private enterprise.

### **The industry voice**

AECOM’s strongly held view is that the infrastructure industry needs to become more vocal about the positive contribution that it makes to people’s lives.

When communities are properly consulted, informed and engaged in dialogue, they become powerful allies, enabling ambitious projects. When Los Angeles County passed Measure M — an estimated US\$120 billion sales tax ballot measure designed to fund improvements to its highway and wider transportation network — over 71 percent of local residents voted in favor of the measure.<sup>1</sup>

Having the civil infrastructure debate openly — and on a human level — can elicit a sense of ownership among local communities and smooth the path to approving and financing new projects, as well as much-needed upgrades. Wider community engagement will also help to generate support for tariff-based payment models and other alternative funding solutions.

It is telling that many of the biggest success stories are occurring in isolation on a local or regional level. Despite plans to overhaul the United States’ infrastructure network at a federal level,<sup>2</sup> performance across the country is inconsistent.

We also see a mixed picture when we look at the cities that are judged by our respondents to be performing well.

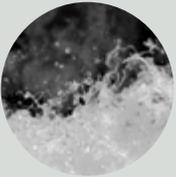
The varied responses from U.S. participants in the survey highlight this disparity between the best-performing cities and regions and those lagging behind. Across all major areas of infrastructure, the same three cities — New York, Los Angeles and Washington, D.C. — are judged as being far ahead in terms of the progress they are making.

<sup>1</sup> <http://theplan.metro.net>

<sup>2</sup> [https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/budget/fy2018/fact\\_sheets/2018%20budget%20fact%20sheet\\_infrastructure%20initiative.pdf](https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/budget/fy2018/fact_sheets/2018%20budget%20fact%20sheet_infrastructure%20initiative.pdf)

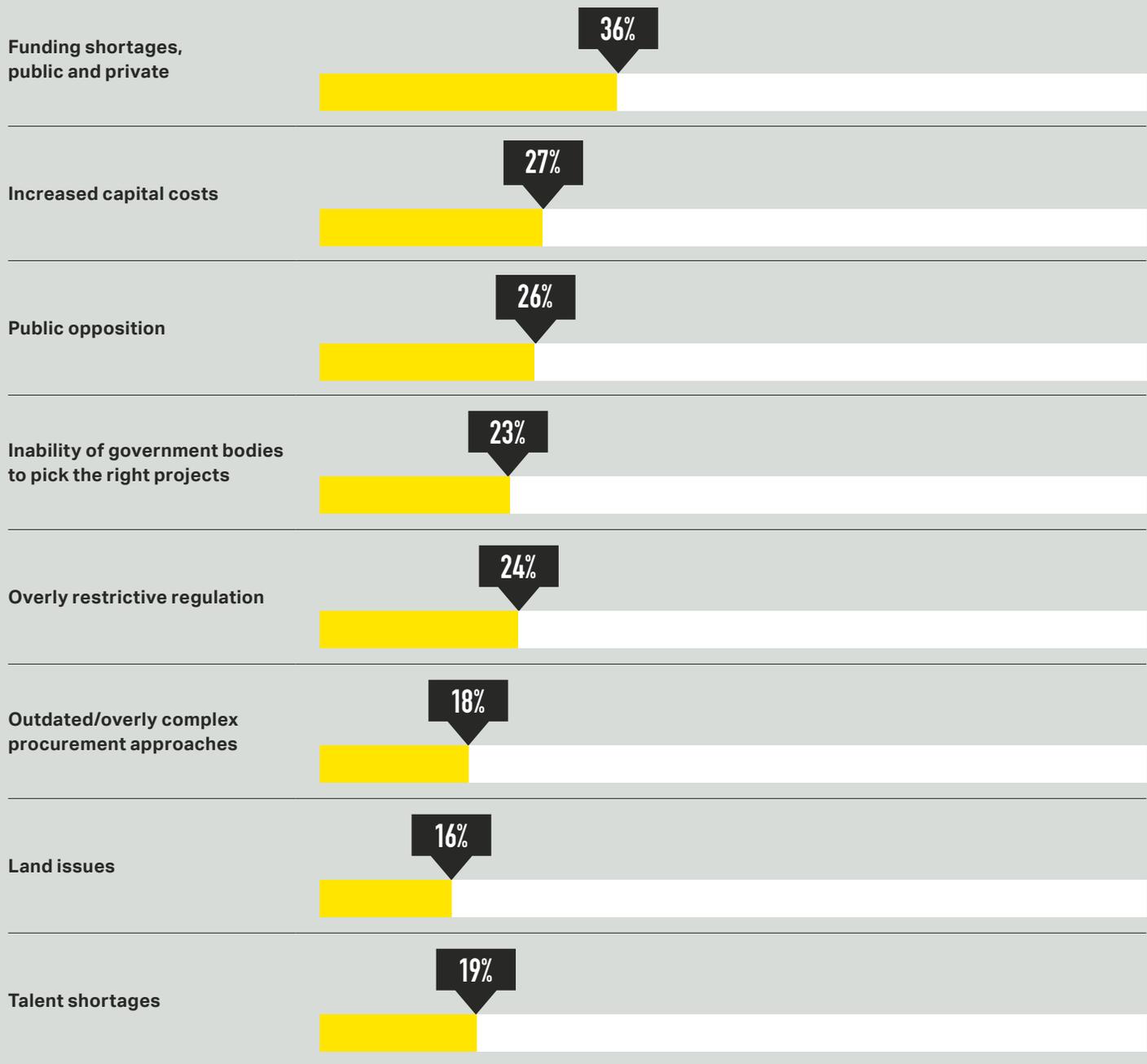
**Figure 2/**

**How respondents rank major U.S. cities on their progress in delivering future-ready infrastructure**

	<b>Transportation</b>	<b>Energy</b>	<b>Ports and waterways</b>	<b>Water resources</b>	<b>Wastewater</b>
					
<b>1</b>	New York	New York	New York	New York	New York
<b>2</b>	Los Angeles	Los Angeles	Los Angeles	Los Angeles	Los Angeles
<b>3</b>	Washington, D.C.	Washington, D.C.	Washington, D.C.	Washington, D.C.	Washington, D.C.
<b>4</b>	Chicago	Seattle	Miami	Chicago	Chicago
<b>5</b>	Houston	Houston	Seattle	Miami	Seattle
<b>6</b>	Seattle	Chicago	Chicago	Seattle	Miami
<b>7</b>	Miami	Miami	Houston	Houston	Houston

**Figure 3/**

**Respondents in North America who describe these issues as major reasons why projects fail to proceed**



Agree



The use of toll-based roads and highways is gaining traction in the U.S. It's a way to fast-track new projects, as it eliminates the government's obligation to find the money from the public purse.”

—  
**Peter Rogoff, Chief Executive Officer, Sound Transit**

### Beyond the funding gap

In our research, inadequate funding is the largest perceived inhibitor of progress in the infrastructure industry. More than one-third of North American survey respondents cite funding shortages as the number-one constraint in getting new projects off the ground.

Our respondents are not alone in having this viewpoint. According to McKinsey, 11 of the world's 20 largest economies, including the U.S. and several leading E.U. member states, have reduced infrastructure spending as a proportion of GDP since the global financial crisis.<sup>3</sup> The consultancy finds that the world needs to invest an average of US\$3.3 trillion annually to keep pace with projected growth through 2030. At the same time, the OECD says US\$71 trillion is required by 2050. And the G20 believes that US\$94 trillion is needed,

---

## US\$3.3 TRILLION

The world needs to invest an average of US\$3.3 trillion annually to keep pace with projected growth through 2030

and a US\$15 trillion gap needs to be bridged by 2037.<sup>4</sup>

Our view is that the funding gap is an issue that must be solved collectively at the federal and local levels by strengthening long-term funding sources for infrastructure, while sparing private-sector investment and state and local spending.

The survey identifies ways to meet the costs of building new infrastructure and maintaining existing assets. Among the more than 300 North American professionals consulted, a majority say innovative funding models are highly effective as a way to mitigate a shortfall. One popular solution, gaining recent momentum in the U.S., is to use public-private partnership (P3) models: approximately half of respondents select P3s as a way to improve traditional procurement.

P3-based models are not the only game in town. Many professionals would like to see user-based funding models built on enhanced approaches to traditional toll-gathering solutions (see Figure 4).

There may well be a place for new tariff-based solutions in cities — including advanced electronic toll collection and open-road tolling — whereby users can contribute directly to the cost of maintaining and improving essential transit infrastructure.<sup>5</sup>

It is critical to develop new channels to deliver funding to infrastructure projects. A significant proportion of survey participants also highlights the need for dedicated infrastructure funding that is protected within national budgets.

<sup>3</sup> <http://www.un.org/pga/71/wp-content/uploads/sites/40/2017/06/bridging-global-infrastructure-gaps-full-report-june-2016.pdf>

<sup>4</sup> <https://outlook.gihub.org>

<sup>5</sup> <https://www.accenture.com/us-en/service-accenture-transit-tolling>

### The way forward

A solution to the funding issue may be achievable, but the industry still faces many challenges as it looks to deliver the future infrastructure that society needs. In our research, respondents believe the industry is at a pivotal moment and that urgent action needs to be taken. They call for a fresh look at the process of infrastructure project delivery.

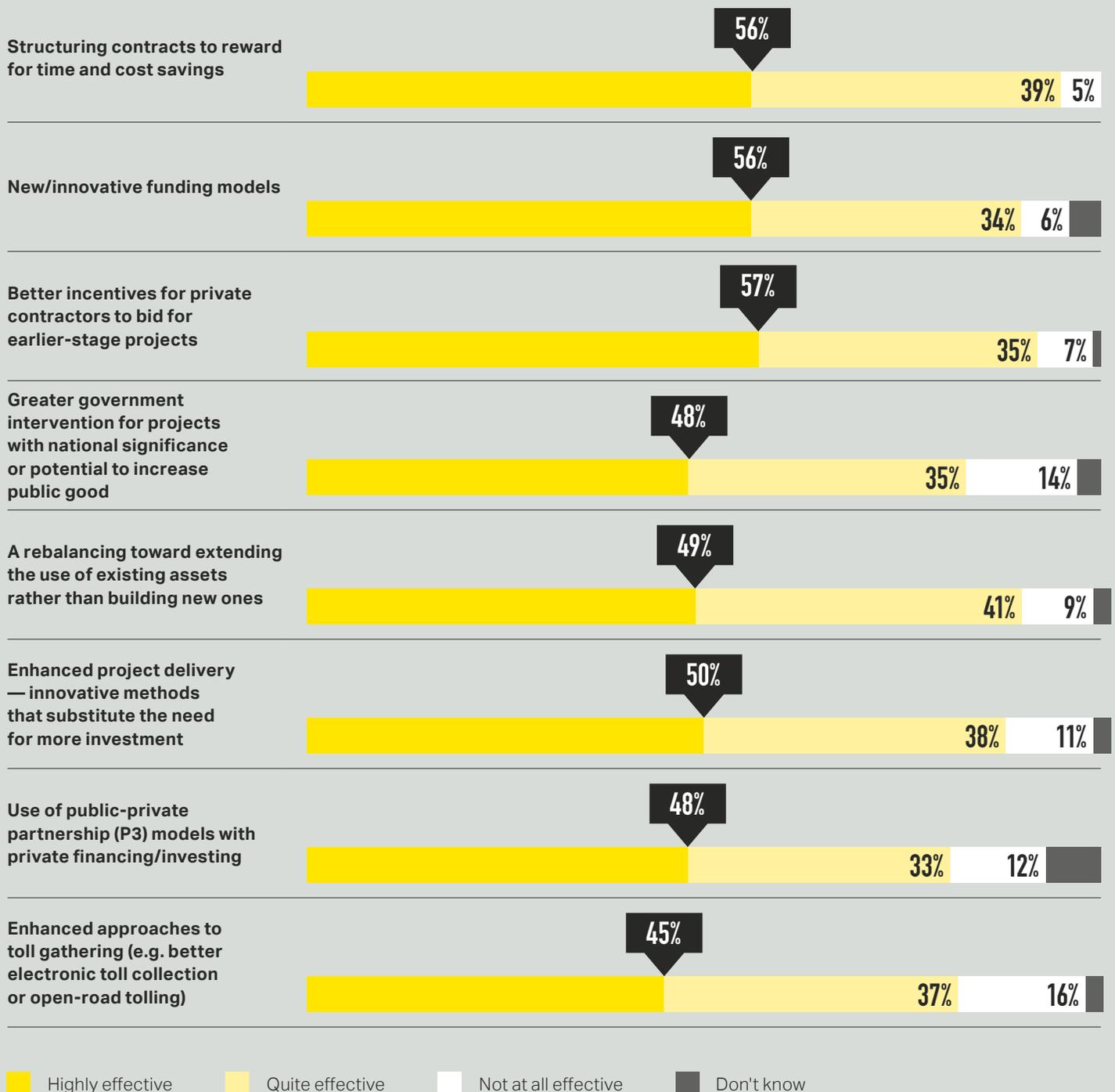
Significantly, respondents see increased support — from central government as well as local communities, businesses and environmental groups — as essential in keeping up with rapid demand for new projects. In the following sections, we explore these ideas in more detail and set out a new approach to resilience.

The consequences for all those involved in the funding, delivery and operation of infrastructure are far-reaching.



**Figure 4/**

**Proportions of respondents in North America that consider the following to be effective solutions to the infrastructure funding gap**



# THE INFRASTRUCTURE GAP: FINANCING AND FUNDING THE FUTURE

With increasing urgency to resolve the financing and funding of future infrastructure, **Michael S. Burke**, Chairman and Chief Executive Officer at AECOM, and co-author and Specialist Consultant, **Clive Lipshitz**, outline several approaches that, taken together, can help reduce the infrastructure gap.

The full version of this article is available at: [infrastructure.aecom.com](http://infrastructure.aecom.com)

**W**ith massive infrastructure needs around the world, and against a reality of constrained public-sector budgets, bold leadership is needed to prioritize assertive public policy, harness private capital, and bring innovation to infrastructure funding and project delivery. While many of our observations and recommendations apply globally, much of the focus in this article pertains to the United States.

## FOUR APPROACHES TO BRIDGE THE GAP

There are no silver bullet solutions. And, given the stakes, inaction is not an option. What is required is a combination of approaches aligned behind a strong vision, transparency, innovation, a conducive regulatory and permitting environment, and willing partners — across borders, governments and industries — that can rise above complicating factors and build trust that leads to confidence in proceeding.

In this spirit, we look at four approaches that, taken together, can be helpful in reducing the infrastructure gap.

### 1/ PUBLIC-PRIVATE PARTNERSHIPS

Public-private partnerships (P3s) are an effective way of transferring life-cycle costs of infrastructure from public-sector budgets and creating investable assets for the private sector. We expect that the P3 market — which is quite evolved in the United Kingdom, Australia and Canada — will deepen in the United States as concession terms become standardized and as valuation transparency is enhanced from higher transaction volumes.<sup>1</sup>

<sup>1</sup> Market failure in valuation is epitomized by the case of Chicago's parking meter P3, which was valued by the city's inspector general at US\$1 billion more than the city received from the concession partner. See <http://chicagoinspectorgeneral.org/publications-and-press/public-reports/igo-report-closely-examines-parking-meter-lease-recommends-major-reforms/>

## 2/ A REGIONAL APPROACH TO INFRASTRUCTURE

The U.S. has numerous authorities that operate — and have been responsible for developing — significant portions of the nation’s infrastructure. Their advantages? These bodies take a long-term and expansive view of infrastructure needs.

Governments seeking to advance P3s in a programmatic manner might adopt the successful model of infrastructure offices, such as the U.K.’s Infrastructure and Projects Authority and Canada’s Infrastructure Ontario and Partnerships BC. The role of these centers is, among other things, to spur P3 activity through encouraging enabling legislation, prioritizing projects, and interfacing between procurement agencies and private capital sources.

## 3/ BETTER MODELS FOR FUNDING OF INFRASTRUCTURE

Whether financed by public or private capital, there is much that can be done to enhance funding models for infrastructure assets.

### Generate sustainable revenues through fair-usage charges

Many infrastructure assets, particularly in the transportation and water/waste sectors, are subsidized or free to users. This is not uniformly sustainable and so we recommend

a reality where, in the words of the American Society of Civil Engineers (ASCE), users “pay ... rates and fees that reflect the true cost of using, maintaining and improving ... infrastructure.”<sup>2</sup>

### Creatively utilize value-capture techniques

Land and property values increase, sometimes dramatically, when they benefit from adjacent infrastructure. Value capture leverages the increase in real estate valuation to fund infrastructure development.

### Ensure dedicated and robust state and local sources of funding

Stressed state and local budgets inevitably lead to maintenance backlogs, which is why it is of prime importance that local sources of maintenance funding be developed from tax revenues and safeguarded, protecting them from being diverted to other budgetary needs.

### Modernize the gas tax

The U.S. Highway Trust Fund, which finances most federal government spending for highways and mass transit, is funded primarily from gasoline taxes. Because wear and tear on roads is correlated much more closely to mileage driven than to gasoline usage, the fund could be stabilized using a mileage-based revenue source that accounts for both gasoline-powered and electric vehicles.



**INFRASTRUCTURE INVESTMENTS ARE WELL SUITED TO THE PORTFOLIOS OF THE WORLD’S LARGEST AND MOST PATIENT POOLS OF INVESTMENT CAPITAL.**

## 4/ ENCOURAGING GREENFIELD DEVELOPMENT

Development of new infrastructure requires substantial capital and entails significant risks. We propose several approaches to address these challenges.

### Government-subsidized construction financing

As in many other countries, the U.S. has governmental programs that subsidize financing for infrastructure development. We believe that budgets for these programs should be expanded, as they are an effective way of providing leverage to federal funds, from private capital and state or local public capital, in the development and maintenance of infrastructure.

### Asset recycling

An effective way to leverage public capital in a resource-constrained environment is to fund new infrastructure via “asset recycling,” whereby proceeds from the lease of existing assets are redeployed in the development of new infrastructure.<sup>3</sup>

### Mitigate risks for private investors

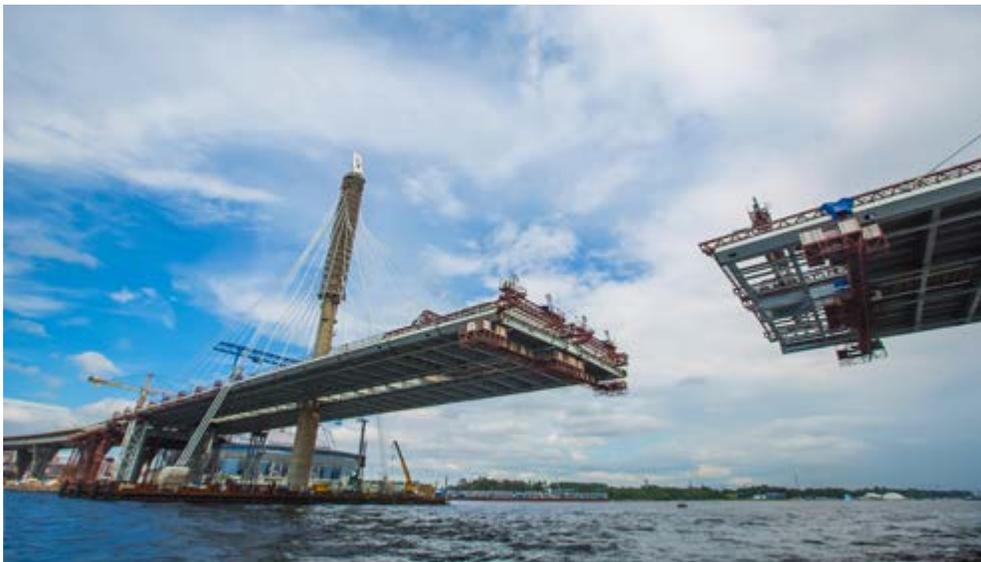
Private capital is generally unwilling to invest in greenfield development because of the difficulties in accurately budgeting development costs and timelines, and forecasting future revenues in the absence of operating history. These risks can be mitigated by inclusion of the right partner in the development and operating consortium.

### Reform regulatory and permitting practices

Predictable regulatory guidelines and efficient permitting processes can be helpful in driving private investment into infrastructure. Policies set by one administration or legislature can fall away with the next, creating uncertainty.

### Conclusion

As we have argued, there are practical steps that can be taken right now by participants in the infrastructure market, as well as public policy initiatives that we actively support. In future articles we expect to expand our scope beyond the United States. **WI**



<sup>2</sup> American Society of Civil Engineers, 2017 Report Card, <https://www.infrastructurereportcard.org/solutions/investment/>

<sup>3</sup> Asset recycling has been used extensively in Australia where the federal government historically provided incentives (usually 15 percent) on top of lease proceeds.





## Part Two

---

# A Pivotal Moment for Infrastructure

### In brief

---

**01/** Rapid urbanization and population growth are putting existing networks and systems under strain as demand far outstrips supply

**02/** Traditional ways of working are no longer fit for purpose and need to change

**03/** Digitization is providing innovative tools and opening up new opportunities, particularly in transportation

**04/** With new skills and approaches, the workforce of the future will be more diverse, increasingly collaborative and highly innovative

---

More than eight in 10 of the North American industry professionals consulted by AECOM agree that this is a pivotal time for civil infrastructure. The industry needs to play a vital economic and societal role in supporting technological progress and shaping the communities of tomorrow.

---

Our respondents share a willingness to embrace challenges and develop fresh approaches to longstanding problems.

There is a clear desire for collaboration and knowledge sharing. This includes a desire to work with other stakeholders, to learn from the industry’s successes and failures, and to take inspiration from elsewhere. But this must be done sooner rather than later.

#### Breaking point

Rapid urbanization and population growth are already putting increasing strain on the infrastructure of major cities — and beyond — and that strain is set to increase. In 1990, less than 15 percent of the global population lived in cities with populations of more than a million. According to forecasts by *The Economist*, that number is projected to rise to more than 27 percent by 2030. By then, nearly nine percent of the population will live in mega cities of 10 million or more.<sup>1</sup>

North America’s cities will experience brisk growth, with the number of urban dwellers on the continent growing from 300 million to 345 million between 2015 and 2030.<sup>2</sup>

The problems aren’t unique to the developed world. In China, for instance, 100 million rural workers

are expected to move to cities between 2014 and 2020.<sup>3</sup> How do we provide current and future infrastructure for this growing population?

#### New tools to deliver faster, smarter and better

The emergence of new technology will certainly help the industry respond to the demands of societal change. Recent years have seen some hugely exciting developments.

Transportation is being completely transformed by digital railways and autonomous vehicles. Hyperloop transportation systems — high-speed “pod”<sup>4</sup> travel between cities — will follow. At the same time, beyond transportation, we have entered the era of the smart city. The pioneers of high-tech, intelligent urban environments, such as Chicago, Amsterdam and Singapore, are using emerging technologies — from data analytics to sensors and the internet of things (IoT) — to govern better, increase environmental sustainability, and improve the networks and systems that support the everyday lives of residents.<sup>5,6</sup>

And yet, to make the most of the new tools available, the industry needs to learn how to overcome some significant emerging challenges.

<sup>1</sup> <http://www.economist.com/node/21642053>

<sup>2</sup> <https://www.eea.europa.eu/data-and-maps/figures/urban-trends-by-world-regions>

<sup>3</sup> [http://www.ey.com/publication/vwluassets/ey-publication-china-planning-for-an-urban-future/\\$file/ey-china-planning-for-an-urban-future.pdf](http://www.ey.com/publication/vwluassets/ey-publication-china-planning-for-an-urban-future/$file/ey-china-planning-for-an-urban-future.pdf)

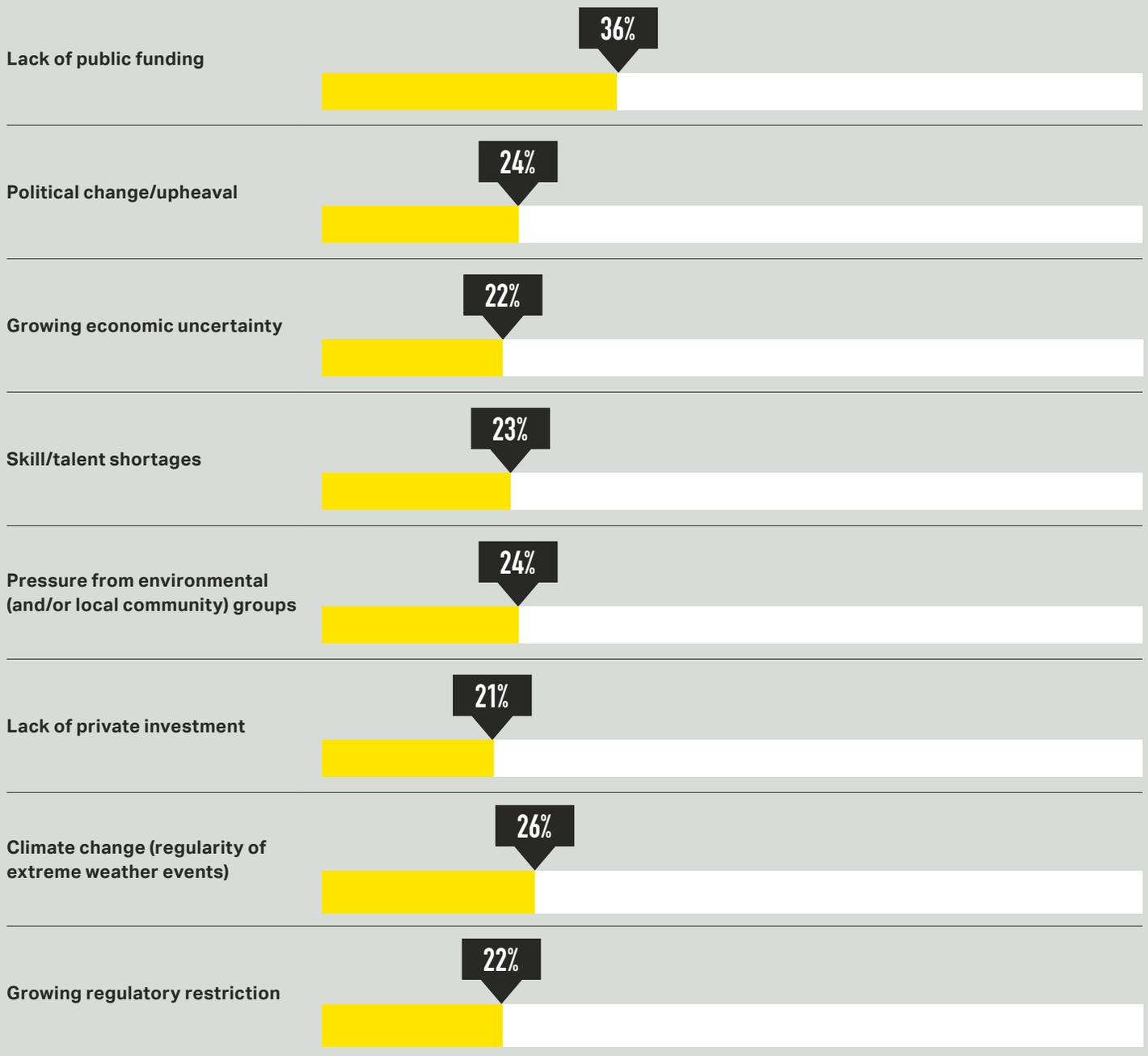
<sup>4</sup> <https://www.designboom.com/technology/delft-hyperloop-pod-high-speed-travel-10-16-2017>

<sup>5</sup> <https://sensus.com/internet-of-things/smart-cities/>

<sup>6</sup> <http://www.ioti.com/smart-cities/why-chicago-smart-city-king>

**Figure 5/**

**Respondents in North America who think the following could significantly impact or restrict the industry's ability to deliver major civil infrastructure projects in the coming five years**



 Agree



New technologies, such as automated vehicles, are racing ahead of the public policy to support them.”

—  
**Therese McMillan, Chief Planning Officer for the Los Angeles County Metropolitan Transportation Authority (LA Metro)**

### Managing external pressure

For many industry professionals, their ability to adapt to a changing society will be reduced by external factors. Around one-quarter of North American respondents to our survey see political upheaval or economic headwinds as potential stumbling blocks to progress in the next five years.

Meanwhile, respondents question the industry’s resilience to a growing range of modern-day threats, including climate change and cyberterrorism.

### Planning and delivery

Respondents to our survey reveal that even major civil infrastructure projects that come to fruition encounter problems, with four in 10 running into significant difficulties, causing major delays. They also indicate that more than one-quarter of projects fail to get going until at least five years after the agreed start date.

Respondents suggest a variety of reasons for this inefficiency. Above all, they point to governance issues: late-delivering partners; unrealistic time frames; poor communication; and ineffective working relationships.

Today’s rapidly growing infrastructure demands create a sense of urgency. Stakeholders are under pressure to deliver projects quickly — often at the expense of clarity and adequate planning.

Poor project and program management is also a major concern. Almost seven in 10 respondents feel that many tried-and-tested approaches fail to meet the requirements of today’s increasingly vast and complex civil infrastructure programs.

A logical inference is that the industry needs to run major infrastructure projects very differently. The entire process should be reviewed — not just funding, but how projects are planned and delivered, how roles are allocated, and how different organizations work together.

An important part of any review of project delivery should be around communication. Nearly three-quarters of survey respondents say that most civil infrastructure projects are a long way from achieving seamless integration between providers. They single out competitive tendering, which is intended to get the best

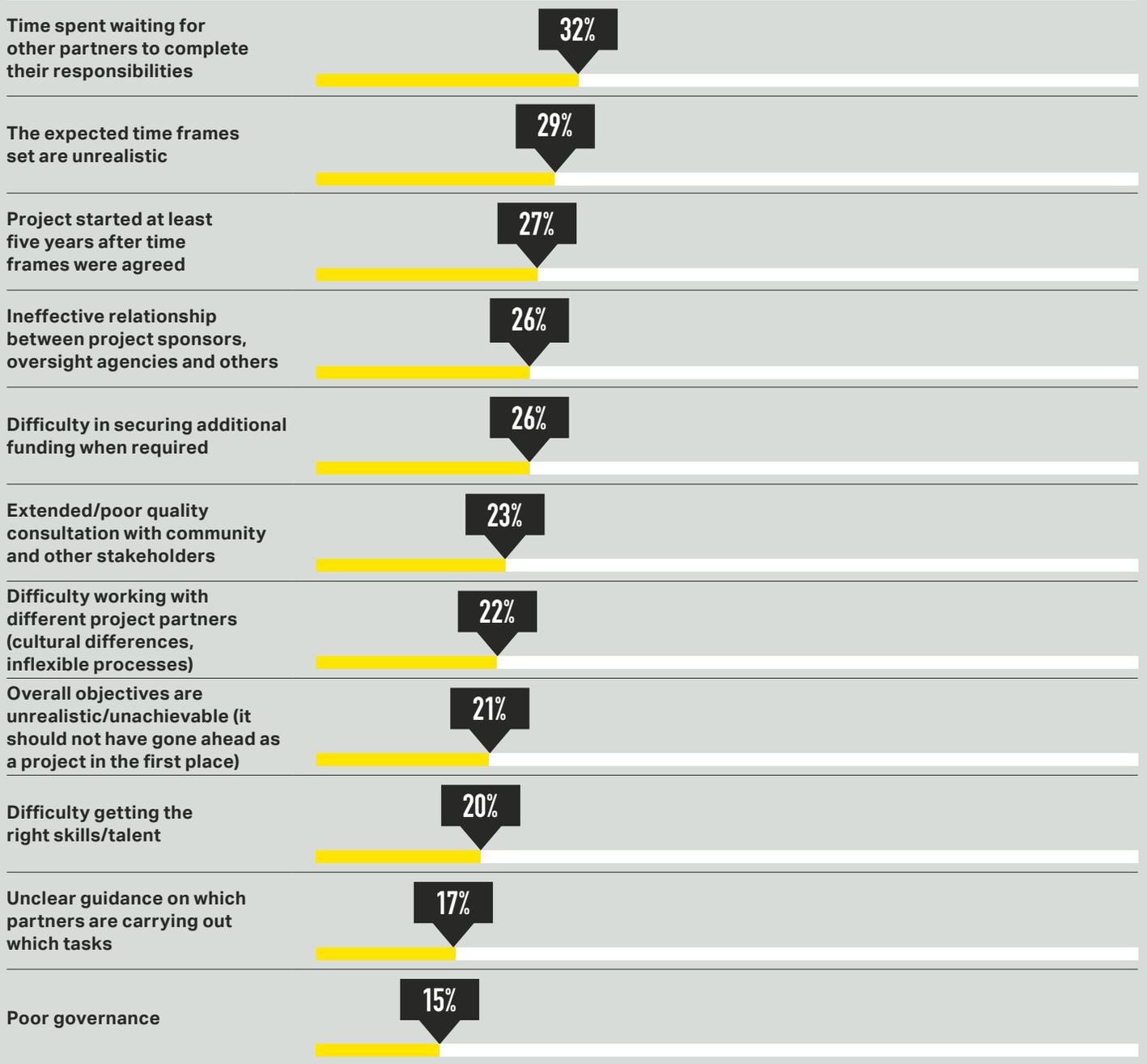
possible value for taxpayers but often imbalances the responsibilities and risks underwritten by different project partners.

Clear communication is also undermined by shielding information from rival bidders. A lack of dialogue means delays and complications. There are cultural drawbacks, too. Civil infrastructure companies engaged in bidding wars are discouraged from sharing best practices with their competitors. And innovations that give a competitive advantage are rarely brought out into the open.

Industry professionals do, however, have some ideas about how to speed up project delivery with different approaches and technologies already in operation around the world. A combination of ideas and methods may be required, and the industry should seek inspiration from the successes and failures of recent years to find the best practice.

**Figure 6/**

**Proportions in North America that say these are the top reasons why major projects run over their expected time frames**



■ Agree

## Figure 7/

### Respondents in North America who rank their organizations as “good” at the following aspects of project delivery



Agree



Voters want to see things moving at lightning speed. We need to build an understanding and manage expectations about how quickly and effectively we can implement change.”

—  
**Therese McMillan, Chief Planning Officer, Los Angeles County Metropolitan Transportation Authority (LA Metro)**

Key to better project delivery is the need to troubleshoot at the early stages of the project life cycle, where delays are most frequent and red tape can prevent new projects from getting off the ground.

Industry professionals also believe that stronger enabling legislation can help accelerate project delivery, while the same percentage call for earlier approval of environmental and other enabling works in the process (see Figure 9).

The broad range of solutions that respondents came up with underlines the reality. There is no single way to enhance project delivery.

### **The talent question**

Any serious discussion on the future of infrastructure must address the talent question. In our view, civil infrastructure must take urgent steps to modernize, get better informed and arm itself with future-proofed skills.

Just under one-quarter of the North America survey respondents cite skills and talent shortages as key obstacles to progress, and about one-fifth say that difficulties sourcing the right talent cause major delays (see Figures 5 and 6).

Employers display confidence in sourcing and retaining the core talents — engineering and project management. Attracting individuals to the profession who possess skills in technology and innovation is a far greater challenge.

It may be a question of image. As civil infrastructure struggles to integrate new technologies and practices, its reputation as an industry for top IT and computer science graduates suffers. That doesn't have to be the case — after all, the sector's challenges and opportunities are as inspiring, complex and demanding as those in any industry.

---

**73%**

Nearly three-quarters of North American survey respondents say that most civil infrastructure projects are a long way from achieving seamless integration between providers.



Here in Seattle, which is one of the major technology capitals of the U.S., the infrastructure sector struggles mightily to attract and retain good IT people. They can walk down the street and make a lot more money working for Amazon or Google or Microsoft. We have to find people who are committed to the whole mission of transit just to keep them on board.”

—  
**Peter Rogoff, Chief Executive Officer, Sound Transit**

## Figure 8/

### Proportions of respondents in North America that agree with the following statements about project delivery

Alternative technical concepts present the best opportunity for civil infrastructure projects to adopt innovative solutions from private contractors

80%

In a practical sense, most projects are a long way from achieving seamless integration of providers

73%

A mix of private and public partners presents a range of different interests and priorities, which makes it harder for government to get maximum value

72%

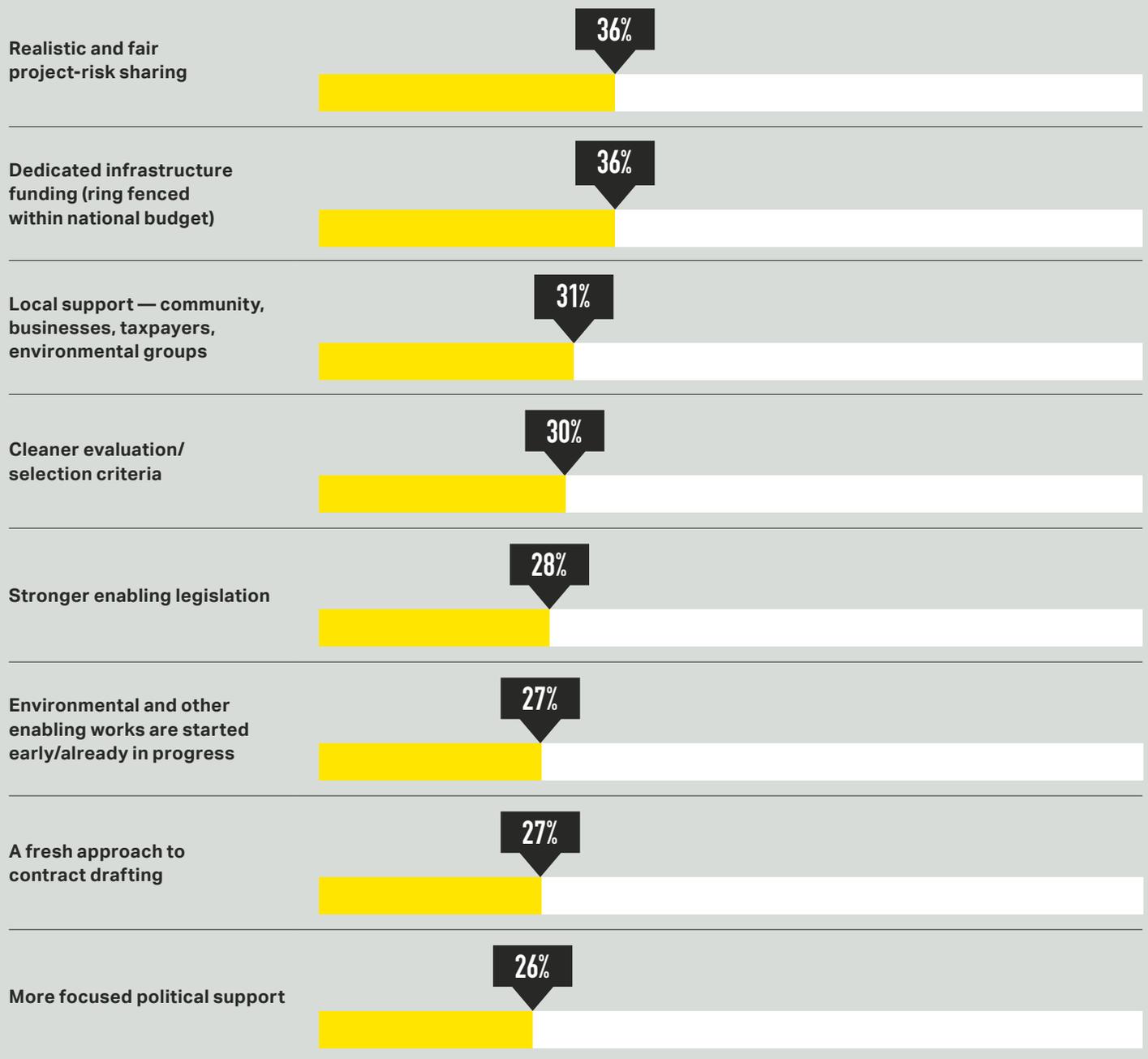
Many of the traditional, tried-and-tested approaches to project management do not fit the demands of today's large, complex programs

69%

Agree

**Figure 9/**

**Respondents in North America who think the following would make a noticeable difference to infrastructure project delivery**



 Agree

# DELIVERING FUTURE INFRASTRUCTURE: FASTER, SMARTER AND BETTER

As the industry seeks to bridge the global infrastructure gap, the delivery of many critical assets — essential to economic growth and the wellbeing of communities — is still being delayed. The combination of technology and alternative delivery can be truly powerful in solving this productivity issue, write industry-leading project delivery experts **Richard Robinson** and **Matt Forbes**.

The full version of this article is available at: [infrastructure.aecom.com](http://infrastructure.aecom.com)

**W**e know that bridging the global infrastructure gap is essential to economic growth and the wellbeing of communities. A swift and effective response to these challenges is currently hampered by inefficient and outdated project delivery methods. We all recognise that this state of affairs must change.

The 500 global industry professionals surveyed in AECOM's Future of Infrastructure report say they have suffered significant yet avoidable delays on 40 percent of recent projects.

The impact on major economies is significant. In the United States, a six-year delay in starting construction on public infrastructure programs manifests as a \$3.7 trillion loss of output across the economy.<sup>1</sup>

And now for the good news — we have the tools and approaches to fix this, but need to kick old habits and outdated ways of working and to build a new industry dynamic.

Our proposed two-step approach to solving the productivity issue embraces first, setting up projects differently to include a more integrated approach that links across the life cycle of an asset, reduces total cost of ownership and creates assets that are more constructible and fit for purpose. And second, deploying digital tools to unlock the full power of this integrated approach, which, in turn, sees the integrated approach release the full power of digital tools. We believe this approach could produce efficiencies of around 30 percent.

<sup>1</sup> [http://www.aecom.com/without-limits/wp-content/uploads/2017/10/Performance-Based-Infrastructure\\_0.4\\_LR.pdf](http://www.aecom.com/without-limits/wp-content/uploads/2017/10/Performance-Based-Infrastructure_0.4_LR.pdf)

Exploring these two items in more detail:

## 1/ SETTING UP PROJECTS FOR SUCCESS

The key here is to break down the familiar silo approach of plan, design, build, and operate and maintain. The following are some key ingredients for successful infrastructure project delivery:

- / Aligning all objectives and rewards across the supply chain to meet the client's key success factors.
- / A more honest dialogue around risk — with suppliers providing greater transparency on the true nature of risk in their own programs and owners willing to absorb more risk directly themselves.
- / Well-designed and performance-based partnership models that ensure all parties have “skin in the game” and are incentivized to deliver the best for the project and client (P3 being an extreme example of this, but other contract structures, such as design build or alliances, provide the opportunity to do this too).
- / Employers resisting the temptation of modifying existing well-defined contract structures, such as NEC in the U.K.
- / Using an organization specifically to act as “integrator” on major projects — managing the interface and relationships between different parties (including small and medium enterprises) across the life cycle — supported by the right technology platforms.
- / Getting the basics right: robust project setup; streamlined governance; and continuous stakeholder buy in.

“  
WHILE THE INDUSTRY HAS WRESTLED WITH ITS PRODUCTIVITY GAP FOR MANY YEARS, THE TIME HAS COME TO EMBRACE INNOVATION AND MAKE THE BIG LEAP FORWARD.”

## 2/ USING TECHNOLOGY TO UNLOCK THE POWER OF INTEGRATED DELIVERY

Digital tools can bring efficiencies in each individual service line, but they also enable the full power of an integrated approach, by providing the following:

- / A digital thread that ensures relevant asset data is passed between the phases of the project life cycle — a “running current” of consistent and appropriate information to all stakeholders through the different stages of building and operating an asset. For example, how much more efficient could maintenance be if asset operators were handed an accurate and reliable picture of the asset they had inherited?
- / Enhanced and automated value engineering to create a more buildable and operable asset. For example, virtual reality (VR) solutions have the potential to merge separate delivery phases by offering an interactive and easily accessible digital design model. Stakeholders — whether owners, design specialists or ordinary users — can “walk through” the design of an asset in the virtual environment; approvals can be given, improvements identified

and safety hazards avoided, minimizing setbacks and the need for re-work later on.

- / Digital engineering techniques, including automated design tools and the growing use of artificial intelligence (AI) and machine learning that not only replace repetitive manual tasks, but also use the power of machines to provide a more reliable outcome. These, in turn, enable new construction techniques such as the use of modular construction, 3D printing and increased use of robotics.
- / Asset intelligence (including the capture and analysis of performance data) to drive more efficient operations and feed back into future designs.

These tools maximize the efficiency of an asset over the whole project life cycle, resulting in lower total cost of ownership and enabling the full power of an integrated offer.

### The future is within sight

While the industry has wrestled with its productivity gap for many years, the time has come to embrace innovation and make the big leap forward. We now have the keys to unlock the future — and they lie in the combination of new delivery models and the smart use of technology. [ML](#)



“  
THE IMPACT ON MAJOR ECONOMIES IS SIGNIFICANT. IN THE US, A SIX-YEAR DELAY IN STARTING CONSTRUCTION ON PUBLIC INFRASTRUCTURE PROGRAMS MANIFESTS AS A \$3.7 TRILLION LOSS OF OUTPUT ACROSS THE ECONOMY.”

For the full article and global Future of Infrastructure Report, visit: [infrastructure.aecom.com](https://infrastructure.aecom.com)

# SKILLS 2030:

## SECURING THE TALENT TO BUILD OUR FUTURE INFRASTRUCTURE

Technologies are transforming our lives and our world, impacting every type of infrastructure you can imagine. This shift requires new skills, and more interdisciplinary specialists. Current industry debate is focused on how the role of the engineer must evolve. In response, **Roma Agrawal** and **Susan Dumond** discuss some of the skills that will be needed in this new era.

The full version of this article is available at:  
[infrastructure.aecom.com](http://infrastructure.aecom.com)

It's 2030. You're hiring. We're already looking at super-fast pod travel. Autonomous vehicles are the norm, and clean power generation has successfully seen the replacement of most fossil-fuel-driven power stations. This vision of the future demands smarter, more sustainable, resilient and innovative infrastructure solutions as default, and you need a new generation of talent.

The challenges are familiar — they include training an interdisciplinary workforce, unleashing their imagination and expertise to solve future problems, anticipating which

innovations and technologies will be in the ascendant, attracting a more diverse and inclusive workforce, and working much harder to tell our extraordinary and inspiring stories.

Most pressing for the industry is the issue of how to train, attract and retain the engineers needed to deliver our smarter networks and systems. Over the next decade or so, we'll continue to see new technologies disrupt the infrastructure sector in ways we can't even imagine now, creating new kinds of industries and jobs as well as making others obsolete.





Based on our research, we believe these are the top five skill areas that will set the 2030 engineer apart:

## 1/ NEW RULES. NEW ROUTES

It won't just be an engineering degree that gets you through the door. The future infrastructure industry is going to be hungry for people qualified in IT, communications, art and design, and life sciences.

## 2/ ACROSS COMPANIES, SECTORS AND BORDERS

As infrastructure programs grow in complexity and geographical scope, the ability to collaborate and work effectively in multidisciplinary teams across different organizations will be invaluable.

## 3/ INNOVATING ACROSS THE PROJECT LIFE CYCLE

The future engineer will use present-day innovations such as BIM, AI and 3D printing as standard. They will be expected to identify and take advantage of the efficiencies that these and other innovative tools, such as sensors and robots, will deliver.

## 4/ AND WHAT DO YOU DO HERE?

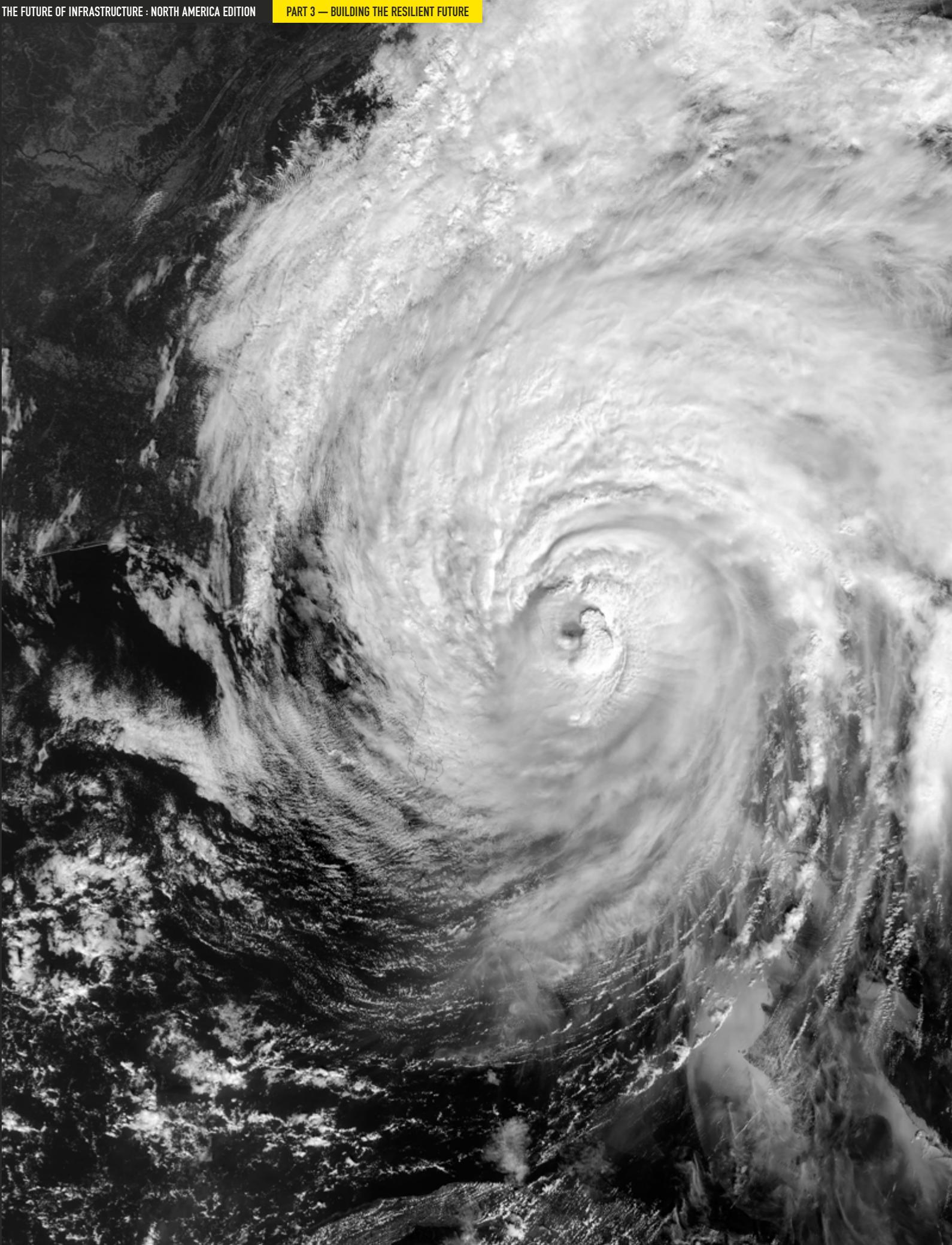
It's increasingly likely that the jobs of the engineers of the future will fall into three main categories:

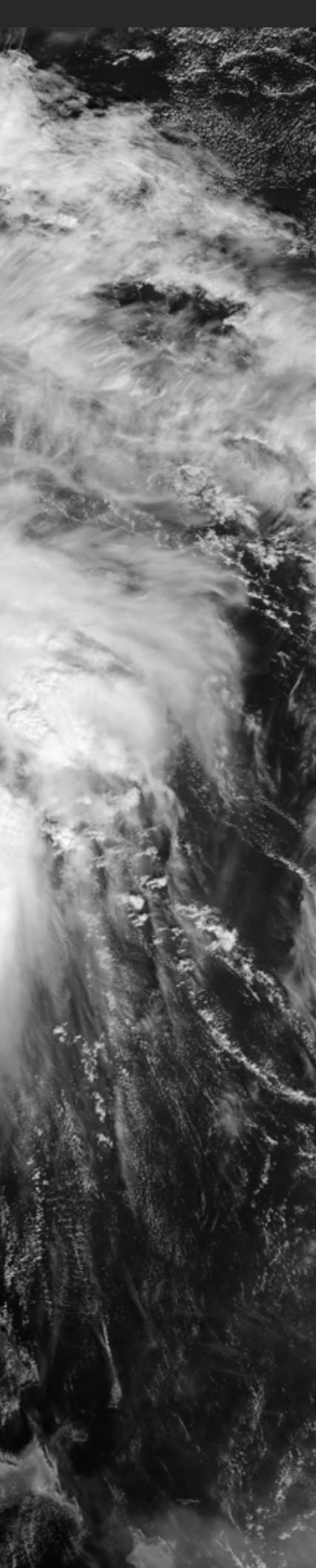
- / **Generalists** — technical experts, also equipped to provide in-depth knowledge of clients' key infrastructure challenges, from finance to regulation and program management.
- / **Data specialists** — coders, programmers and analysts brought on board to harness the benefits of the latest technologies, and mine the growing volumes of smart data being generated for insights.
- / **Client advisors** — strong communicators focused on providing the best in customer service, and working as the face of their organizations.

## 5/ AGILE AND CULTURALLY AWARE

With projects now crossing continents, and global trends such as urbanization and aging demographics driving the speed of change even further, the future engineer must be able to respond rapidly to the latest industry developments and tailor their ways of working to the diverse needs of international clients. 

For the full article and global Future of Infrastructure Report, visit: [infrastructure.aecom.com](https://infrastructure.aecom.com)





## Part Three

---

# Building the Resilient Future

### In brief

---

**01/** Around one-third of industry leaders believe a major cyberattack is almost certain to happen in the near future

**02/** A high proportion of infrastructure professionals feel ill equipped to deal with major events

**03/** To support economic growth and social prosperity, future proofing and protection against cyber and physical attack are essential

**04/** Early investment will help mitigate the significant repair costs after cyber- or climate-related disruptions

---

It is easy to get excited about the future. We all like to imagine a world of autonomous cars, digital railways that anticipate and help improve reliability, and Hyperloop links to usher in a whole new way of traveling.

---

Yet autonomous cars need roads to drive on, and digital rail systems and Hyperloop links have to interact seamlessly with legacy transport networks. When our North America survey respondents were asked about the infrastructure trends that will define the sector over the next five years, such non-traditional and disruptive projects ranked close behind the more predictable “hygiene” projects relating to essential services.

Infrastructure owners — as well as those entrusted with delivering projects — must find ways to keep pace with technological change. This will require clear, long-term thinking from both central and local government. Private-sector providers will also need to be incentivized to help find solutions for a growing array of complex problems.

We need to upgrade existing networks and systems as well as create new ones; embrace innovation in the ways we work and the infrastructure we rely on; and ensure that the infrastructure we create is resilient and future proofed to help withstand the shocks and stresses to come.

### **Cyber: A countdown to catastrophe?**

In today’s digital world, protection against cyberattack is one of the most critical aspects of resilience. When asked about the likelihood of certain events occurring in the next five years, respondents give a sobering assessment. About one in three believes that catastrophic events — a major ransomware attack or city-wide transport disruption — are almost certain in the near future.

The fact that many industry professionals don’t feel equipped to deal with this growing menace is troubling. Two-thirds of respondents are highly pessimistic about their peers’ ability to anticipate a full-scale cyber event, however many feel their own organizations are able to respond to change and unexpected events.

Infrastructure must be modernized, and the industry must become better informed about ensuring resilience and arming itself with relevant future-proofed skills.

**Figure 10/**

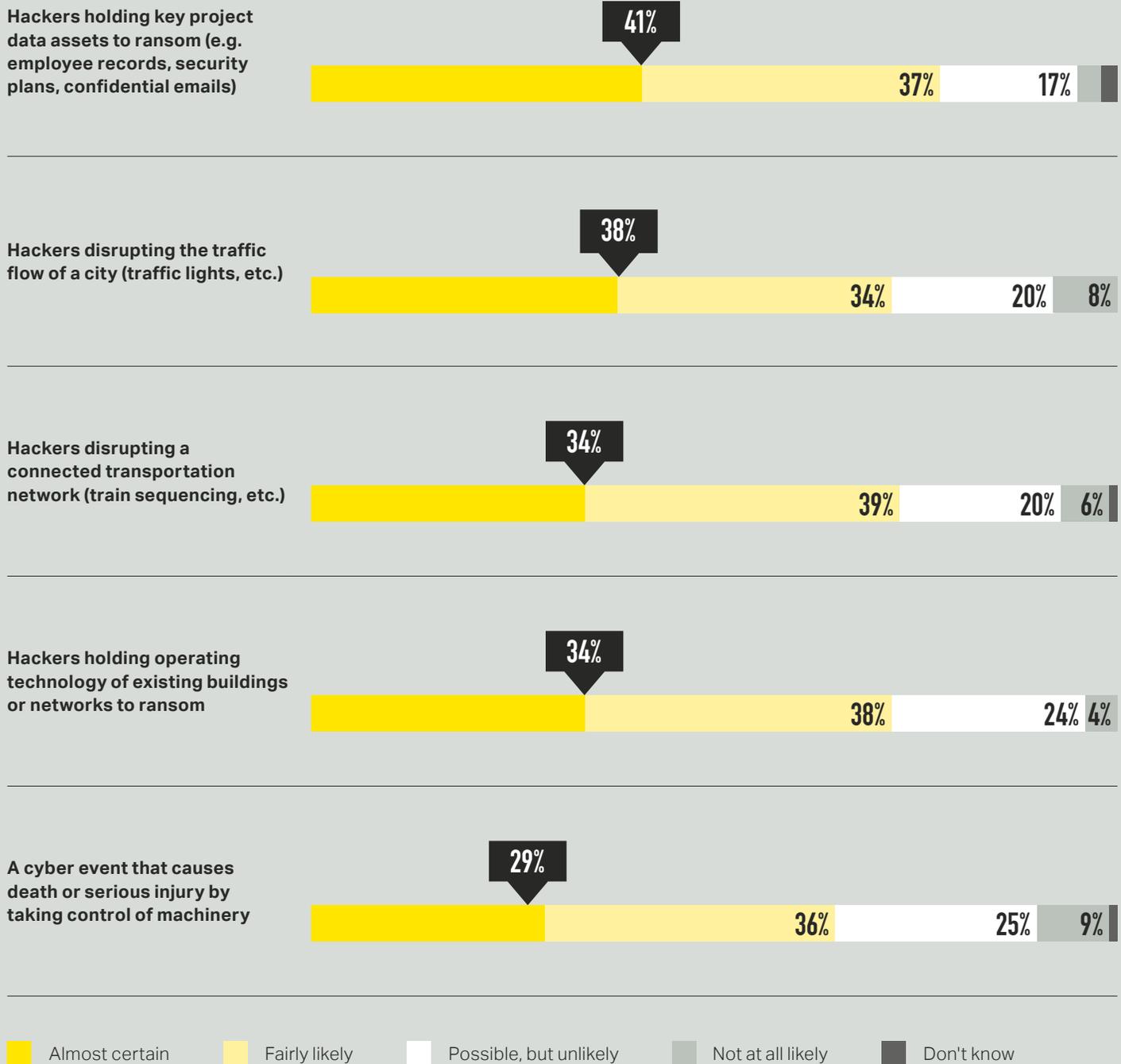
**Respondents in North America who see these as major infrastructure trends in the coming five years**



 Agree

**Figure 11/**

**How respondents in North America rate the likelihood of several major cyber events taking place in the next five years**





Lack of preparedness may put some systems at particular risk. Cyberterrorist groups are playing on the fact that some of our systems are dated and, therefore, not as secure as some of the more modern systems. Obviously, the solution involves not presenting ourselves as an attractive target.”

—  
**Peter Rogoff, Chief Executive Officer, Sound Transit**

### Essential innovation

Infrastructure professionals are aware of the unique economic and social sustainability role facing the industry over the coming decade. But new ideas and approaches are needed for industry players to prepare for what is to come.

Together with improving the ways that infrastructure assets are funded, designed, built, operated and maintained, integrating new technologies can have the additional benefit of attracting much-needed new talent. It can help solve the sector’s image problem and create a virtuous circle — an influx of new technical skills attracts younger generations who, in turn, increase the tech skills and freshen up the image even further.

### Ideas from business

Of the more than 300 North America industry professionals surveyed, the vast majority share a clear appetite for deeper engagement with the private sector — particularly when it comes to technology and innovation, but also sustainability and resilience more broadly.

Nearly one-quarter of respondents believe that creating incentives for private-sector innovation will make the greatest difference in driving new technology solutions within civil infrastructure. A substantial proportion think it will be key to meeting future sustainability challenges.

## 1 IN 3

About one in three believes that catastrophic events — a major ransomware attack or city-wide transport disruption — are almost certain in the near future.



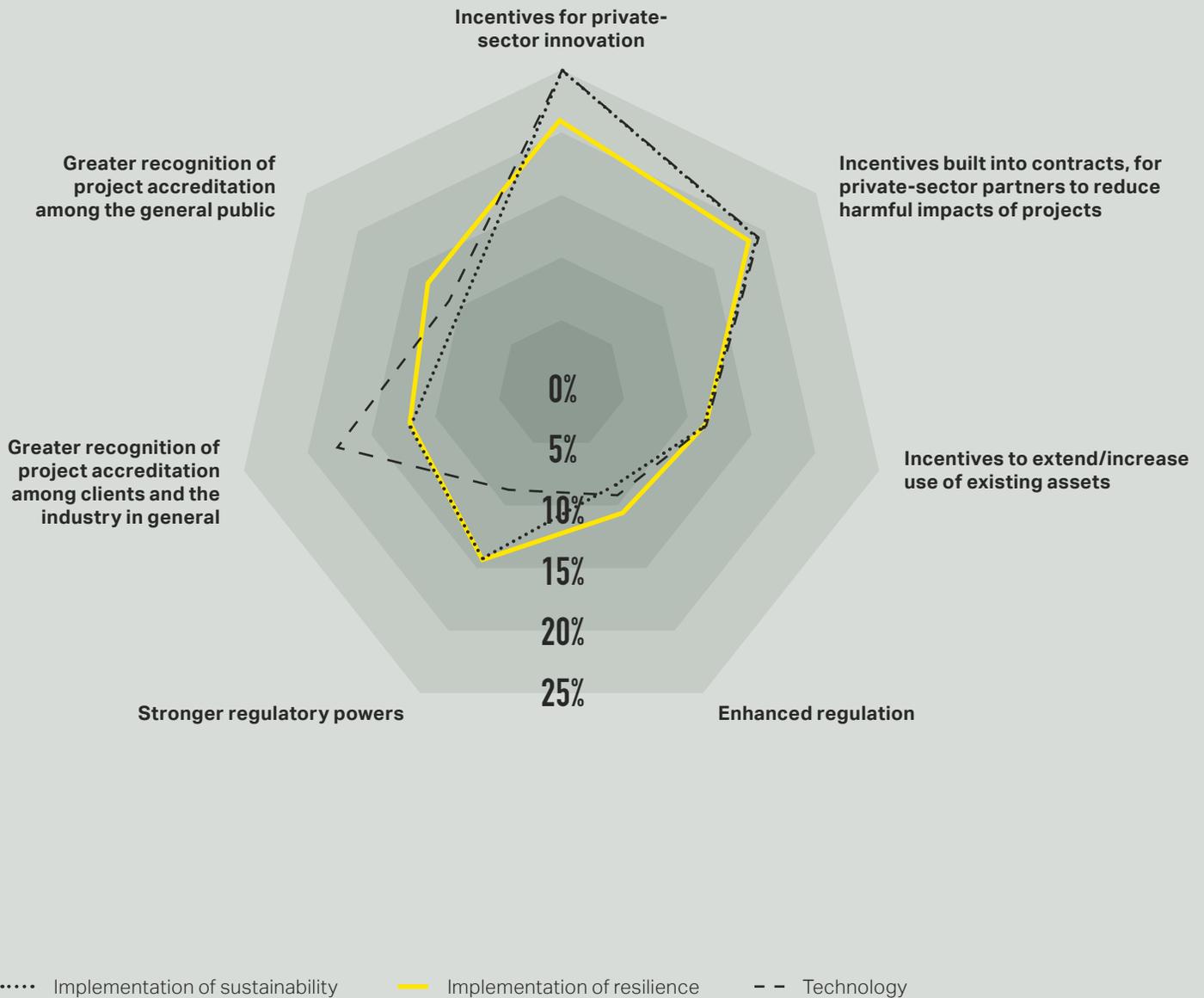
The private sector is leading a lot of interesting discussions on innovation in infrastructure. This is a very positive thing. How the marriage between public and private happens in the U.S. is in a state of transition. As a public-sector leader, this is one of the more pressing things that we need to get our heads around.”

—  
**Therese McMillan, Chief Planning Officer, Los Angeles County Metropolitan Transportation Authority (LA Metro)**

<sup>1</sup> <http://digital-built-britain.com>  
<sup>2</sup> [https://www.designingbuildings.co.uk/wiki/digital\\_built\\_britain](https://www.designingbuildings.co.uk/wiki/digital_built_britain)  
<sup>3</sup> <https://www.nic.org.uk/driving-innovation-in-infrastructure-through-artificial-intelligence>  
<sup>4</sup> [http://www.civil.hku.hk/cicid/1\\_about\\_cicid.htm](http://www.civil.hku.hk/cicid/1_about_cicid.htm)

**Figure 12/**

**Proportions of respondents in North America that say these initiatives would make the greatest difference to key areas of organizational behavior**



# RESILIENCE: IN A SHIFTING WORLD

The new generation of infrastructure will be smarter and more efficient, but with high performance also comes vulnerability. Future proofing civil infrastructure projects is one of the biggest challenges facing the industry, write infrastructure resilience experts **Ronald Hahn** and **Josh Sawislak**.

The full version of this article is available at:  
[infrastructure.aecom.com](http://infrastructure.aecom.com)

**S**afe, secure and resilient infrastructure is a lifeline to our future. It is the differentiator between successful and struggling economies and societies.

To be durable and futureproof, the infrastructure of tomorrow must cope with, and adapt to, a complex, extensive and evolving mix of hazards, risks and threats. As a result, resilience must now be an essential component of every project across its entire life cycle — integrated from the planning and design phase — and not just added on as a last-minute feature.

Cybersecurity firm, Kaspersky Lab found that 40 percent of the world's infrastructure had been the subject of

a cyberattack during the second half of 2016.<sup>1</sup> In 2017, hurricanes in the U.S. and the Caribbean alone caused more than US\$265 billion in damage.

The changing infrastructure landscape has created the need for holistic, industry-wide solutions for identifying and managing risks. AECOM has developed a holistic approach called Converged Resilience™, which acknowledges the interdependency of the physical and digital worlds — and uses this understanding to build lasting, integrated strategies for infrastructure resilience.

So, what should infrastructure organizations do to prepare to manage these risks effectively?

<sup>1</sup> <https://www.infosecurity-magazine.com/news/40-of-ics-critical-infrastructure/>

# 5 POINT PLAN FOR A CONVERGED RESILIENCE™ FRAMEWORK

**Converged Resilience™ provides the approach for a lasting resiliency strategy. While each organization and situation is different, it is possible to apply a common framework to the problem. The goal is to simplify the risk-management process while allowing the flexibility to cope with a broad range of scenarios across the digital and physical environments.**

## 1/ START EARLY

For maximum impact, a resiliency strategy must be introduced as early as possible in the lifespan of an asset. The industry has often viewed resilience as an add-on to the core design-build process, and that is too late.

This may link back to the industry's binary view of the physical and digital worlds. We still see examples, such as during the construction of an airport building or a rail track — when plans for introducing the IT and security systems are started after the physical asset has been built.

For infrastructure owners, the goal must be to build in resilience planning as early as possible — the sooner a protection framework is implemented, the more cost efficient and effective it becomes.

## 2/ UNDERSTAND THE RISK

Having early-stage conversations about risk management makes it easier for an organization to customize a resiliency strategy. First, this means knowing which assets to protect, as well as, more importantly, understanding the function of those assets and the potential cost of losing or devolving that function. Beyond simple replacement cost, what is the business case for determining which assets to protect and how? Through efforts such as the 100 Resilient Cities program (100RC) pioneered by the Rockefeller Foundation, municipalities are taking a strategic approach to understanding, not only the risks, but also the interaction of the risks and different urban systems and goals.<sup>2</sup>

## 3/ PRIORITIZE TO OPTIMIZE

It is impossible to eliminate risk completely. If its assets are aging, an infrastructure owner will need to select where to focus its resiliency investment. Consider where most effort and resources need to be focused. In addition to functionality, the service life of an asset and the feasibility of replacing it must come into consideration.

<sup>2</sup> <http://www.100resilientcities.org/focus-impact-evidence-first-four-years/>

<sup>3</sup> [\ "page104" http://www.keepeek.com/Digital-Asset-Management/oe.cd/economics/investing-in-climate-investing-in-growth\\_9789264273528-en#page104](http://www.keepeek.com/Digital-Asset-Management/oe.cd/economics/investing-in-climate-investing-in-growth_9789264273528-en)

# 4/

## ACCEPT, MITIGATE OR TRANSFER

With new vulnerabilities constantly evolving, infrastructure owners must decide how to manage the many risks they face.

The first option is to accept the risk and manage it internally with the resources available. A second option is mitigating risk as new threats emerge by adapting or retrofitting an asset. The goal is to restore functionality, either fully or partially, in the fastest time.

The third approach is to transfer the risk; for example, by creating a back-up facility that can quickly take on the functionality of the original asset. When this is not feasible, a company or municipality may look to transfer a much larger proportion of risk to the insurance market.

It is important to understand, however, where that risk is transferred to ensure it is managed effectively. For example, leasing a second data line into a facility from a different provider than the primary line may transfer risk, but only if it is a different physical path that is not connected to the primary line.

# 5/

## ENHANCE

Building infrastructure resilience cannot be a one-time investment. Just as being healthy requires a certain lifestyle, resilience demands a new way of operating.

Having put a strategy in place, it is essential that the protection plan is revisited and updated regularly. Continuous risk mitigation must be the goal. The threats are constantly evolving. Business changes, government changes, environments change, compliance increases, technology is exploding — it is crucial to stay engaged and agile.

### Conclusion: Business case for resilient infrastructure

Investing in infrastructure resilience can be an expensive and time-intensive process, but it is a necessary one. Early planning not only mitigates the impacts of disruption, it also creates interesting net benefits. For example, the introduction of on-site renewable energy into an organization's energy mix creates distributed generation. This is effective, as it introduces resilience into the grid. At the same time, there are enormous benefits from a sustainability- and fuel-reduction standpoint, and it can create a hedge to fluctuations in energy costs.

Looking at the bigger picture, infrastructure-focused, climate-change initiatives have the potential to offer positive effects for the wider global economy while generating market advantages and goodwill with customers, employees and investors.

• According to OECD projections, the infrastructure investments needed to support the shift toward a low-emission society would generate fuel savings of up to US\$1.7 trillion a year worldwide through 2030.<sup>3</sup>

Organizations of all shapes and sizes should take heed. Risk affects every one of us. The public and private sectors have a responsibility — whether it is to their shareholders or constituents — to balance the books and to generate growth. Building resilience is a critical part of this business case. <sup>WL</sup>

# STRANGER THAN FICTION: A DAY IN THE LIFE OF FUTURE INFRASTRUCTURE

As new technologies revolutionize the infrastructure industry, **Veronica Siranosian** and **Andrew Bui** from the AECOM Ventures team look at emerging infrastructure trends to imagine life in 2030.

In a city in 2030, it's morning. The built world continues to evolve at unprecedented speed. You're asleep in your new environmentally efficient home, constructed more durably, precisely and cost-effectively, due in large part to 3D printing technologies.

## A world designed for you

Slowly, the blinds covering your solar windows rise. Every fitting, fixture and system in your home is designed to sense and react to your needs. Some, such as your smart walls, are made of programmable materials that respond to external stimuli. Others are directed by sensors controlled by you.

As you blink awake, you turn on two translucent screens close by. One brings up your virtual assistant, the other the morning's headlines.

## Managing water, sustaining life

Today, there's good news. In response to increasingly extreme weather events, there's an innovative web-based flood forecasting and early warning system for the Kosi River Basin — one of India's most vulnerable sites to flooding. It will help to protect communities during the heavy monsoon season.

At the same time, the world cannot afford to waste this excess water. The demand for fresh water is rising.<sup>1</sup> But we are draining resources faster than they can be replenished.<sup>2</sup>

There's help from the systems built into homes, offices and other facilities to capture, store and treat rainwater for everyday use. And some countries are exploring building ecosystems to transfer flood water to storage reservoirs.

Tighter global emissions regulations are also driving innovation and investment to reduce the extraction of natural water resources.

Advances include the use of microbubbles. This technology, which can be fitted to new and existing treatment plants, generates smaller bubbles to complete the purification process cheaper, faster and more sustainably.

Power stations, too, are becoming a thing of the past. More homes are powered by super batteries that store and use energy generated via renewable solutions.

## Space for living

As you step into the bathroom, you check your own fresh water stores and limit yourself to a three-minute shower — then get dressed. Before leaving, you rearrange the flexible internal walls of your home to create a spare bedroom for a visiting friend.

Currently, your home is located in a central community hub, and every day the space around you is changing.

More people are relying on walking, biking, public transportation, and mobility-as-a-service (MaaS) providers — who operate fleets of autonomous electric vehicles<sup>3</sup> — as faster, safer and cheaper alternatives to owning their own car. And chunks of urban and curbside real estate once filled with vehicles are being reclaimed for the community.

In fact, your new home is located in a former multi-story parking lot, repurposed in record time using 3D printing technologies to provide access to sustainable, affordable homes.

<sup>1</sup> <http://www.globalwaterforum.org/2012/05/21/water-outlook-to-2050-the-oecd-calls-for-early-and-strategic-action/>

<sup>2</sup> <http://onlinelibrary.wiley.com/doi/10.1002/2015WR017349/full>

<sup>3</sup> <http://www.aecom.com/blog/infrastructureweek-innovating-today-to-improve-how-we-get-there-tomorrow/>

<sup>4</sup> <http://www.metro-magazine.com/technology/article/724846/autonomous-vehicles-have-potential-to-deliver-array-of-benefits>



## Putting your best foot forward

Your nearest mobility hub includes options to take public transportation, or share a ride via a MaaS journey. Your transit agency app — which uses AI and digital sensors across transportation systems to analyze data relating to demand, delays and constraint issues — alerts you that your usual multi-modal journey has changed, due to a concert in the park. Based on your travel preferences, the app advises you of your new journey, which now includes a shared, electric, connected and autonomous vehicle (CAV).<sup>4</sup>

## It's good to talk

These vehicles are available on demand and provide dynamic routing based on passenger origins and destinations in real time.

The introduction of CAVs, combined with MaaS, improved “connected vehicle” services, shared vehicle use, and sustainable fuels, is revolutionizing transport. Connected vehicle technologies allow transport systems, infrastructure and smart devices to speak to each other and process big data to enable connected vehicle services (for example, smart routing). Automated technologies enable vehicles to respond in real time, without driver input, and avoid potential dangers, such as missed red lights, speeding vehicles and sudden stops, as well as congestion or travel issues. These vehicles have also helped to increase the mobility of people unable to access or use traditional vehicles in the past.

Smart powered lanes help CAVs to go the distance, using wireless technology that enables these vehicles

“**EVERY FITTING, FIXTURE AND FEATURE IN YOUR HOME IS DESIGNED TO SENSE AND REACT TO YOUR NEEDS.**”

to charge their batteries as they drive on the road at full speed, making range anxiety a thing of the past. Any excess energy generated through these journeys can be used to power people's homes, workplaces and communities.

As you ride over a bridge, one of its smart sensors highlights a problem in the infrastructure. In minutes, the bridge's internal intelligence system alerts a maintenance team to the fault, orders a replacement part to be 3D printed, and schedules the fix.

## Pods on Demand

You carry on unaware. As your CAV bus drops you off at the nearest mobility hub to your office, you complete your journey with a Pod on Demand (PoD). These next-generation PoDs are a sustainable, cheap and fast way to move around.

Your PoD moves seamlessly from road to sidewalk, directed by connected and autonomous technologies, navigating its way between pedestrians and other vehicles efficiently, safely and smoothly.

When you get to work, you don't go up. You go down to your organisation's deep-basement offices. Your workspace is several floors in total, each one lower than the last, offering meeting rooms, restaurants and shops, as well as sleeping pods if you have to work late.

The energy-efficient trap lights, which run throughout the building, use photoluminescent pigments to capture and give out light. This, alongside a glass atrium, helps to keep the structure bright.

## Express delivery

At midday, you receive a call from a supplier letting you know that the goods you ordered that morning will be delivered in 30 minutes by Hyperloop. This high-speed technology enables goods and passengers to be transported comfortably and seamlessly in pods capable of traveling at subsonic speeds through low-pressure tubes.

Crossing hundreds of miles in a matter of minutes, people and businesses are no longer limited by their location, helping to balance and drive economic growth across the country.

## A virtual journey

After lunch, you and a colleague plan for a major upcoming building project. Using Augmented Reality (AR), you digitally recreate the planned finished building and walk through the project. Incorporating digital building information modelling (BIM) data, you're able to highlight potential delays and issues, and contact other team members to discuss possible fixes — weeks before anyone steps on-site.

## Catching a flight home

The afternoon passes quickly, and you stay a couple of extra hours. Tired, you head up to your office's vertiport to take an aviation taxi. The sky above you is increasingly populated by delivery drones, running alongside flying autonomous vehicles, and governed by strict air traffic control rules and initiatives such as designated flight lanes and tolls.

After a short wait, your taxi — a lightweight, electric vertical take-off-and-landing aircraft — arrives to fly you home ready for tomorrow. **WL**



For the full article and global Future of Infrastructure Report, visit: [infrastructure.aecom.com](https://www.infrastructure.aecom.com)

## About this Research

This report has been produced by AECOM in collaboration with Longitude. It is based on two main inputs.

First, we conducted a survey of 509 civil infrastructure professionals from three regions: North America, APAC and Europe. Please note, North America comprises 274 from the U.S. and 26 from Canada; the APAC region consists entirely of 50 respondents from Australia; (qualitative interviews include representatives from the wider region). Europe comprises 109 from the U.K., 45 from the Republic of Ireland, and five from Germany.

Respondents work in a range of sectors related to civil infrastructure. All respondents work on projects exceeding US\$100 million, and 43 percent work on projects exceeding US\$500 million.

The research was carried out online. Respondents were not compensated for their participation and AECOM was not identified as the research sponsor.

Second, we conducted qualitative interviews with a range of senior figures in the civil infrastructure industry. AECOM was identified to this group as the research sponsor.

## Acknowledgments

AECOM would like to thank all of the contributors and partners involved with this research.

## Authors

### The Infrastructure Gap: Financing and Funding the Future

**Michael S. Burke, Chairman and Chief Executive Officer of AECOM:** Building his vision of AECOM as the world's premier integrated infrastructure firm, Mr. Burke has been instrumental in the firm's evolution. He is Co-Chair of the Steering Committee, Infrastructure and Urban Development Industries, World Economic Forum.

**Clive Lipshitz, Investment Strategist:** Mr. Lipshitz has extensive experience within global asset management firms designing, developing, and marketing alternative investment products, particularly infrastructure and real estate strategies. With a strong interest in addressing challenges facing the largest institutional investors, he

has undertaken and published solutions-oriented research into pension plans at Stanford University and New York University.

### Delivering Future Infrastructure: Faster, Smarter and Better

**Richard Robinson, Chief Executive, Civil Infrastructure, EMIA:** Richard leads the delivery of an integrated design, build, finance, operate approach to AECOM's client service and brings experience in these areas from across the chemical, manufacturing and transport industries.

**Matt Forbes, Chief Operating Officer, Digital Transformation:** Matt heads up AECOM's global Digital Transformation initiative. He has extensive experience of setting strategy, designing operating models and driving operational excellence within the construction industry, both across the individual service lines of design, build, finance and operate, as well as in integrated life-cycle models.

### Skills 2030: Securing the Talent to Build our Future Infrastructure

**Roma Agrawal, Structural Engineer, AECOM:** With her strong belief in the potential of the engineering profession, Roma is a tireless promoter of engineering, scientific and technical careers to young people, particularly underrepresented groups, such as women. She has advised policymakers and government on science education, and has spoken to thousands at universities, schools and organizations worldwide. Many of her projects are large scale — from skyscrapers, including The Shard in London, to footbridges and train stations. Her awards include the Royal Academy of Engineering's prestigious Rooke Award.

**Susan Dumond, Ph.D., Senior Vice President, Global Talent Management:** Committed to enabling people to contribute their best work every day, Susan has guided AECOM and other Fortune 500 companies in the transformation of their businesses and delivered talent strategies that attract, develop and retain the talent required to deliver business results.

### Resilience: In a Shifting World

**Ronald Hahn, Executive Vice President, Critical Infrastructure Protection Strategies:** A cybersecurity and counter-terrorism expert, Ronald leads AECOM's business in providing an innovative approach to critical infrastructure protection, cybersecurity and physical security solutions. He has advised numerous government organizations on security strategies and solutions, including the National Security Agency and NATO.

**Josh Sawislak, Global Director of Resilience:** Josh works across the entire enterprise of AECOM's offerings in planning, design, construction, finance, operations, and development to help develop and leverage climate and disaster-resilience strategies. He previously served in the U.S. Government as a senior White House official in the Obama Administration leading climate adaptation efforts and infrastructure resilience for disaster recovery.

### Stranger Than Fiction: A Day in the Life of Future Infrastructure

**Veronica Siranosian, AICP, Director, AECOM Ventures:** With a background in public- and private-sector urban planning, Veronica develops and delivers mobility and smart city strategies and projects that integrate technology and innovation. She has managed and prepared technology feasibility studies, pilot design, and deployment for first-of-their kind projects across multiple modes, including connected and automated vehicle technologies and Hyperloop.

**Andrew Bui, Director, AECOM Ventures:** Andrew is a registered engineer and drives strategy development for new transportation and mobility technology integration and its impact on transportation infrastructure planning, design and construction. He has led feasibility studies for new emerging technologies including Hyperloop, connected and autonomous vehicles, and electric vehicle infrastructure as well as design and management of major roadway and transit projects, including work on California High Speed Rail, LA Metro's Regional Connector, and several Southern California highway projects.

This report was produced by AECOM's Strategic Marketing team.

We would also like to thank Sam Bousfield, and credit Samson Motors, Inc. for the image of the Switchblade vehicle and access to their white paper on the Future of Transportation.

## Disclaimer

AECOM would like to thank all clients, partners and project teams for their help in producing this publication. Every effort has been made to ensure accuracy, give credits and trace copyright holders where appropriate. If any have been inadvertently overlooked, the necessary arrangements will be made at the first opportunity to amend the publication.

© 2018 AECOM. All Rights Reserved.

## Contacts

For further information on this report, please contact [infrastructure@aecom.com](mailto:infrastructure@aecom.com)

Harriett Hindmarsh  
Vice President, Enterprise Strategic Marketing  
[harriett.hindmarsh@aecom.com](mailto:harriett.hindmarsh@aecom.com)

# WITHOUT LIMITS

Imagine it. Delivered.

## About AECOM

AECOM is built to deliver a better world. We design, build, finance and operate infrastructure assets for governments, businesses and organizations in more than 150 countries. As a fully integrated firm, we connect knowledge and experience across our global network of experts to help clients solve their most complex challenges. From high-performance buildings and infrastructure, to resilient communities and environments, to stable and secure nations, our work is transformative, differentiated and vital. A *Fortune 500* firm, AECOM had revenue of approximately \$18.2 billion during fiscal year 2017. See how we deliver what others can only imagine at [aecom.com](http://aecom.com) and [@AECOM](https://twitter.com/AECOM).



To read the full global report, visit [infrastructure.aecom.com](http://infrastructure.aecom.com)



For a personalized reading experience search the Apple App Store for 'Without Limits'.