Global Infrastructure Hub

WORLD ECONOMIC FORUM

BCG BOSTON CONSULTING GROUP

Infrastructure Futures

The impact of megatrends on the infrastructure industry

Foreword

In our conversations with industry leaders, there is a clear recognition that well-established trends are disrupting the sector in a way that is more rapid and profound than experienced in the past.

These trends include the rapid evolution of technology, increasing urbanisation, climate change, compression in expected financial returns in a low rate world, and changing consumer preferences. These are compounded by unprecedented and unpredictable global events, like a pandemic, financial crisis or acts of terrorism. As industry leaders, we need to decide how we are going to respond to these trends. Are we going to be passive and potentially be overtaken by events, or be active and capture the opportunities created by these systematic shifts?

We conducted a survey across more than 400 industry leaders on the megatrends that are most likely to have the greatest impact on infrastructure development through 2050. From these, we constructed three possible scenarios describing the future these trends might create. These scenarios are relatively extreme extrapolations of current trends, but remain plausible. They are designed to foster debate about the type of industry we want to create in the future.

We also tested the implications of these trends. The report highlights several common areas that stakeholders should further investigate to adequately prepare for the future, which include:

- Given the significant shifts occurring, we see a clear need for better coordination between all players to create a positive, rather than a dystopian, future. This will require business models to be anchored in partnership.
- Data and the ability to glean insights on the way assets function, consumers behave and industry competes are a source of competitive tension in all of the scenarios. Government and the private sector must adapt to the increased role of data in the infrastructure sectors.
- The skills mix required within the infrastructure sectors is changing as industry 4.0 reshapes industrial value chains and processes. Grappling with labour market dislocations and upskilling workforces are increasingly urgent agendas for both government and industry.
- Infrastructure is the essential foundation for economic and social activities, yet it is not a given that assets will be built and managed in a way that serves society equitably or safeguards the environment. Ensuring that infrastructure is fully inclusive in the future will take the combined efforts of government and the private sectors.

Our work has clarified that, while many of us know that change is coming, we are collectively under-prepared. This is startling given the economic and social importance of our industry. It also highlights the importance of working in partnership as an industry, as no single company, organisation, or country can manage the many and various economic, political, environmental, and social challenges alone in this interdependent world. The 2020 global pandemic has emphasised the need for rapid and coordinated responses. Our hope is that this report's perspectives highlight the potential costs of delay, and therefore serves as a call to action.

We would like to thank our partners, the Global Future Council on Infrastructure, and the Boston Consulting Group, for supporting this effort, as well as the many hundreds of sectoral experts who shared their views in the survey results underpinning the report.

"This report is intended to provoke thought and spark action, inspiring decision-makers within the infrastructure industry to collectively shape a more cohesive, resilient, and sustainable world. In the face of growing global uncertainty, we have to act now to ensure infrastructure is planned and delivered in a strategic way that contributes to long-term inclusive growth."

Marie Lam-Frendo
Chief Executive Officer
Global Infrastructure Hub

"Well-planned infrastructure is critical to the development of prosperous and sustainable societies, especially at a time characterised by increased uncertainty around our political, economic, and ecological futures. Our work on Infrastructure Future Scenarios will help inform long-term strategies for infrastructure development and ensure that the infrastructure that we build today is able to meet the challenges and seize the opportunities of the future."

Katherine Davisson
Head of Cities, Infrastructure and Urban Services
World Economic Forum

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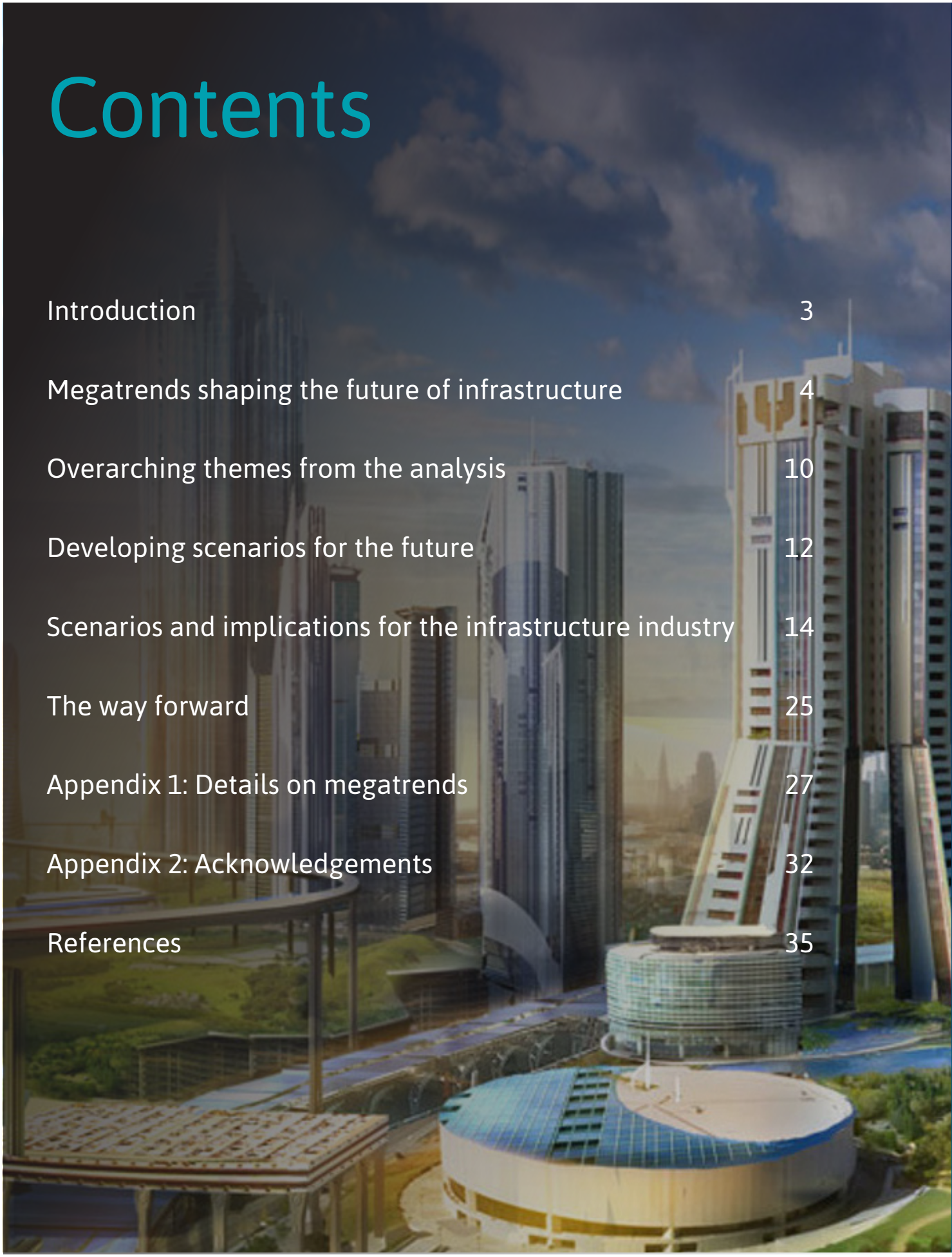


Introduction

Tackling the US$15 trillion infrastructure financing gap is a persistent challenge for the global infrastructure industry. This alone demonstrates the complexity of achieving significant change. Yet, the industry now faces additional transformative trends, from urbanisation to the rapid development of InfraTech, and the intensification of climate change. The industry will need to find new ways of working together to respond to these challenges.

The Global Infrastructure Hub (GI Hub), working with the World Economic Forum (WEF) and Boston Consulting Group (BCG), conducted a scenario-planning exercise to understand how a collection of 25 transformative trends—megatrends—could reshape the infrastructure industry in the future. The exercise involved surveying more than 400 practitioners across 70 countries on the certainty of direction, scale of impact and level of preparedness for these megatrends. The output of this exercise resulted in three scenarios and a set of implications for the infrastructure industry.

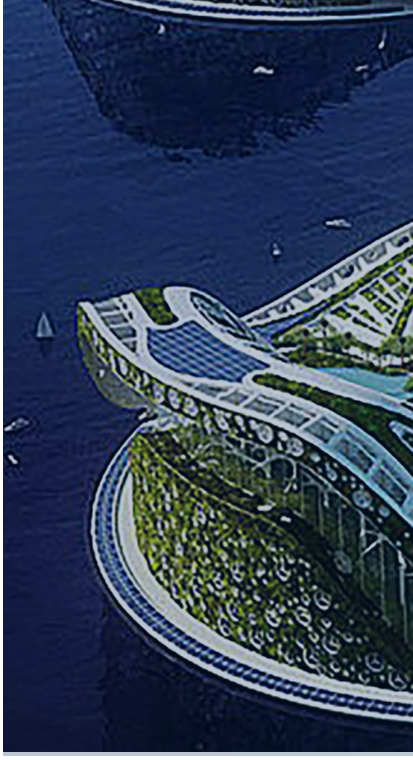
The scenarios constructed in this report are not predictions of the future, but are instead designed to prompt debate. They offer deliberately extreme, yet plausible, versions of the future. The scenarios described are:

- **The Conflicted Planet: A multipolar, isolated world with limited international cooperation and the rise of national infrastructure champions.**
- **The Digital Planet: A corporate-dominated, highly digitised world where the adoption of technology is hyper-accelerated across all infrastructure sectors.**
- **The Green Planet: A world where sustainability is the new main decision criterion, where the circular economy reshapes the infrastructure industry.**

By working through the possible implications of these scenarios on, for example, business models, public policy, national security, investment, and customers, we identify potential government and private sector interventions, as well as perspectives on future investigation and action.

01

Megatrends shaping the future of infrastructure



1.1 Introduction to the megatrends survey and methodology

Megatrends are large-scale, transformative, well-established trends that proceed exponentially. Such trends have the potential to fundamentally change users' needs, shift where value is created, and reshape the nature of competition. Megatrend analysis takes a structured approach to assessing the implications of these trends by gauging industry leaders' views on these trends and then using these views to construct extreme, but plausible, versions of the future. These scenarios are intended as a planning tool, allowing organisations to test the robustness of their strategies against these possible future realities.

For example, governments can test the strength of current public policies against challenges for which they might be unprepared. Similarly private investors and industry leaders might draw insights into the risks that are most likely to impact financial returns. This is particularly relevant for long-term strategic planning and vital in an industry with long asset life cycles.

This report is based on a global survey gathering perspectives on the 25 megatrends most relevant to the infrastructure industry, which are organised into five megatrends domains:

1. Society and workforce
2. Market and customers
3. Geopolitics and regulation
4. Technology
5. Sustainability and resilience

For each of the megatrends, the survey asked members of the infrastructure industry for their views on three dimensions:

- The certainty of both the direction and impact of each trend
- The potential impact of the trend
- The preparedness of the infrastructure industry to handle the trend

Respondents were also asked to identify megatrends that could offer the biggest opportunities and those that pose the most significant risk over the next 30 years.

For the purpose of generating scenarios, the most interesting megatrends are those that are high in uncertainty (involving many possible futures), high in potential impact for the infrastructure industry (involving potentially very different futures) and low in preparedness (involving potential future actions and policies that can make a significant difference). Our analysis of the survey results focuses on these dimensions.

Table 1: Categorisation details
Megatrends by domain

Domain	Megatrend
Society and workforce	Urbanisation and population growth
	Ageing population and workforce
	ESG/corporate social responsibility
	Sharing economy
	Pressure for companies to increase efficiency and productivity
	Rise of health and safety concerns
Market and customers	Demand shift to emerging economies
	Infrastructure financing gap
	Rise of bigger, more complex projects
	Private participation in infrastructure
	Globalisation and international trade
Geopolitics and regulation	Global divide and increased social inequality
	Multipolar world
	Rise of distrust and pressure for increased transparency
Technology	Rise of new materials and substances
	Rise of green energy sources
	Rise of IoT, sensors and smart infrastructure
	Rise of AI and automation
	Autonomous driving and new transport modes
	Digitisation (building information modelling, or BIM, onsite collaboration apps)
Sustainability and resilience	Ageing infrastructure
	Rise of natural disasters and resilient infrastructure
	Rise of climate change
	Resource scarcity and rise of circular economy
	Rise of security risk

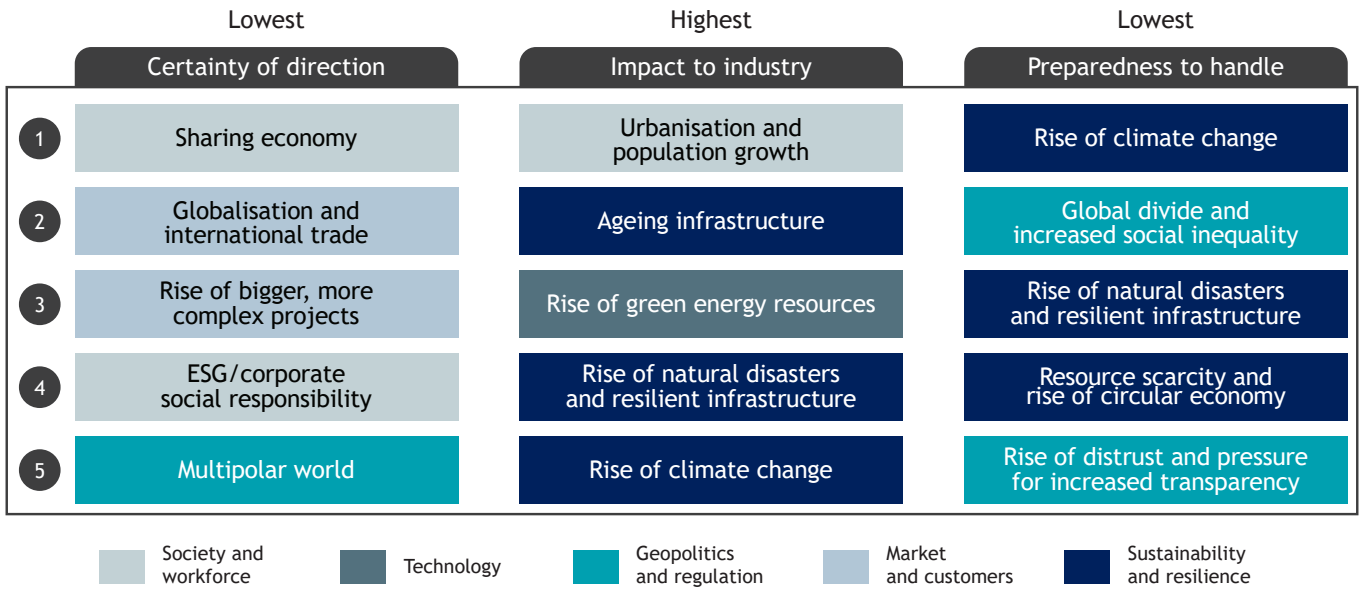
Table 1 illustrates the details of each domain, with further details available in the appendix of this report.

1.2 Survey results

The survey received responses from more than 400 respondents in 70 nations, with 35% of respondents from emerging markets, and 65% from mature markets. All G20 nations were represented. Respondents came from the full spectrum of different organisational types—including government, international organisations, multilateral development banks, contractors and operators, private investors, technology firms, academia and think tanks—and represented all organisational levels, including a large number of CEOs and directors.

The top and bottom five results (of 25 megatrends), across each of the three dimensions, are summarised in Figure 1 (a full ranking of the megatrends is included in the appendix).

Figure 1: Overall survey results
Top five megatrends by dimension



The megatrends with the lowest certainty, as seen in the first column above, and therefore most generative of potential different futures, are clustered in the domains that also have the lowest average certainty overall: society and the workforce, market and customers, and geopolitics and regulation. In particular, it is worth noting the connection between the megatrends of globalisation, international trade, and the multipolar world, suggesting that respondents saw the international environment as one of the major sources of uncertainty for the infrastructure industry.

The megatrends with the highest impact (and therefore the most different potential futures from today) are from the sustainability and resilience domain, which respondents rated as having the second-highest overall potential impact. While the rise of green energy sources was the only technology trend that ranked in the top five megatrends, technology megatrends were all ranked above average in terms of impact, leading that domain to have the highest overall impact rating.[1] If we link the rise of green energy sources to both a technology and a sustainability component, it appears that respondents view the intersection of sustainability *and* technology trends as among the biggest influences on the future of the infrastructure industry.

The megatrends with the lowest preparedness (and therefore for which the most significant potential difference could be made by future actions and policies chosen) are clustered in the sustainability and resilience, and geopolitics and regulation domains (the two domains with the lowest preparedness overall), and overlap significantly with the list of highest-impact megatrends. This suggests that sustainability and geopolitics are viewed as the two areas in which further preparation might be required.

Across the three dimensions, there is a relatively high degree of correlation (0.48) between responses on the 'certainty' and 'impact' dimensions. That is, megatrends that respondents saw as high in certainty were also typically viewed as high in potential impact. Interestingly, there was very low correlation between 'impact' and 'preparedness'. That is, megatrends that respondents saw as very high in potential impact were not more likely to be megatrends that the industry was well prepared for.

Figure 2a: Overall survey results
Top five risks

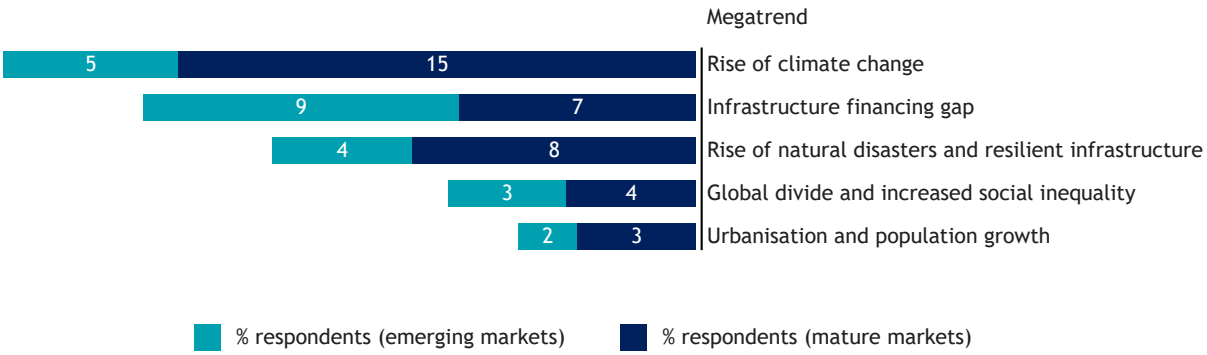
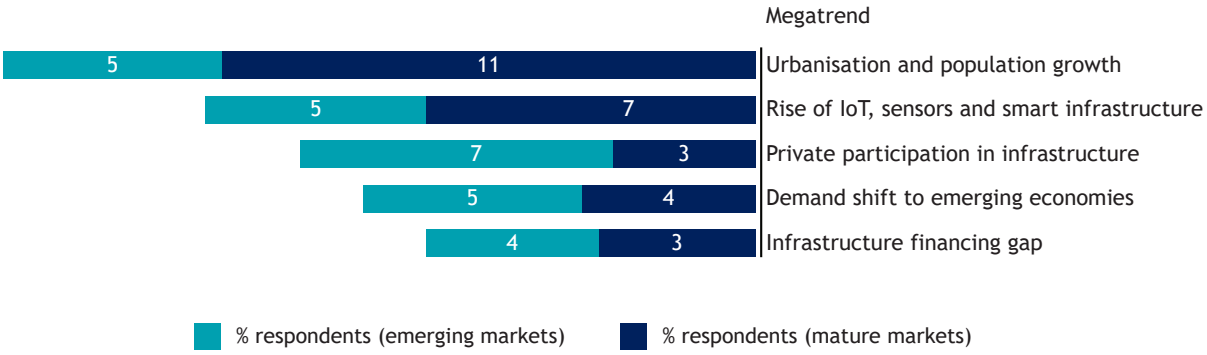


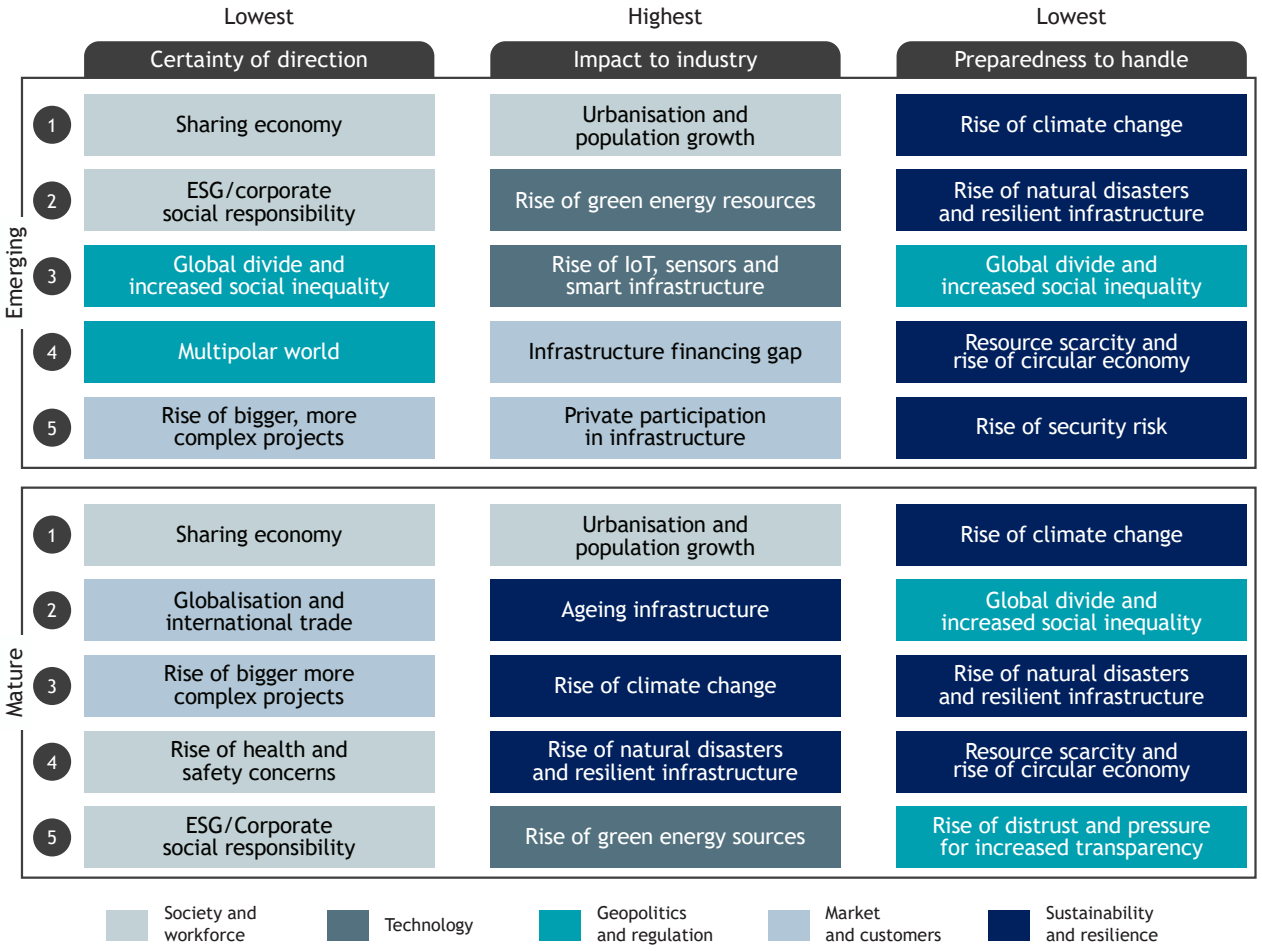
Figure 2b: Overall survey results
Top five opportunities



The trend with the highest perceived risk (Figure 2a) was the rise of climate change, which was also perceived as high impact and the lowest level of preparedness. This trend was highly correlated with the rise of natural disasters and resilient infrastructure. The second most prominent category of risk was the infrastructure financing gap, which is a well-known challenge with much work currently underway to address it.[2]

We also asked participants about opportunities. The trend with the highest perceptions of opportunity (Figure 2b) was urbanisation and population growth, being identified by 16% of respondents. This trend, and that of ageing infrastructure, were highly correlated with climate and natural disaster–related trends, suggesting that many in the infrastructure industry believe that the pressures of urbanisation and ageing infrastructure are likely to compound the effects of climate change and natural disasters. The next-highest-rated opportunity (12% of respondents) was the rise of IoT, sensors and smart infrastructure, which likely reflects the overall opportunities and impact of technology in infrastructure.

Figure 3: Emerging and mature markets survey results
Top five megatrends by dimension



Across respondents from emerging and mature markets, the greatest difference in views was in the megatrends that would have the highest impact (Figure 3). After urbanisation and population growth (which both types of markets agreed on), emerging market respondents focused on technology and financing trends, while mature market respondents focused on ageing infrastructure, the rise of climate change and the rise of natural disasters and resilient infrastructure.

Based on expert discussions, this difference likely reflects the degree of existing infrastructure in each country, with the relatively greenfield nature of emerging markets leading to an emphasis on new technologies and financing, while mature markets with extensive, albeit ageing, infrastructure are focused on green issues and how to recycle, retrofit and make existing infrastructure more resilient. This is reflected in the tension in international discussions, including at the G20, around what is most important in infrastructure, with emerging markets focusing on access and financing and more mature markets focusing on mitigation and resilience.

Both emerging and mature markets shared similar opinions about the certainty of direction of the megatrends and the industry's preparedness to handle them. However, respondents from emerging markets appear to be slightly more focused on the uncertainty in geopolitics and regulation, with the global divide and increased social inequality, and multipolar world featuring more prominently.

To better understand where views of preparedness diverge, Figure 4 shows the perception of lack of preparedness rankings by organisation type.

Figure 4: Infrastructure organisation type survey results
Top five megatrends ranked by lack of preparedness

Academic institution and think tank	Consulting and advisory firm	Contractor and operator	Government
Rise of climate change	Rise of climate change	Rise of natural disasters and resilient infrastructure	Rise of climate change
Global divide and increased social inequality	Rise of natural disasters and resilient infrastructure	Rise of climate change	Global divide and increased social inequality
Resource scarcity and rise of circular economy	Resource scarcity and rise of circular economy	Rise of AI and automation	Rise of natural disasters and resilient infrastructure
Rise of distrust and pressure for increased transparency	Global divide and increased social inequality	Ageing infrastructure	Resource scarcity and rise of circular economy
Rise of natural disasters and resilient infrastructure	Rise of distrust and pressure for increased transparency	Global divide and increased social inequality	Rise of distrust and pressure for increased transparency

International organisation	Investor	Multilateral development bank	Technology firm
Ageing population and workforce	Global divide and increased social inequality	Resource scarcity and rise of circular economy	Global divide and increased social inequality
Global divide and increased social inequality	Rise of climate change	Rise of climate change	Multipolar world
Urbanisation and population growth	Sharing economy	Ageing population and workforce	Rise of distrust and pressure for increased transparency
Rise of natural disasters and resilient infrastructure	Rise of natural disasters and resilient infrastructure	Sharing economy	Ageing population and workforce
Ageing infrastructure[1]	Rise of distrust and pressure for increased transparency[2]	Rise of natural disasters and resilient infrastructure[3]	Rise of security risk[4]

Society and workforce | Technology | Geopolitics and regulation | Market and customers | Sustainability and resilience

Not included in the list but equal to the marked trends were 1. Rise of AI and automation, infrastructure financing gap
2. Multipolar world 3. Autonomous driving and new transport modes 4. Infrastucture financing gap

In aggregate, investors and government officials felt that the infrastructure industry was less prepared for the 25 megatrends compared to other groups of respondents, such as technology firms, or contractors and operators. On the other hand, contractors and operators and international organisations (e.g. the United Nations [UN] or the Organisation for Economic Co-operation and Development [OECD]) felt that the industry was more prepared than other groups. Variances among stakeholders in perceptions of preparedness might indicate that there should be greater levels of communication and collaboration between different groups of stakeholders in these areas to achieve greater alignment across the market.

There was greater agreement on the biggest areas of industry unpreparedness. Global divide and increased social inequality appeared in seven of the eight groups in Figure 4, rise of natural disasters and resilient infrastructure appeared in seven of the eight groups, and the rise of climate change in six of the eight groups. Interestingly, one area where investors felt more prepared was private participation in infrastructure; however, this level of confidence was not shared by the other stakeholder groups, such as government and academia.

02

Overarching themes from the analysis

It is clear from the survey results that there are four key areas for industry, the public sector and the international community to investigate in more detail:

1. Given the significant shifts occurring, we see a clear need for **better coordination between all players** to create a positive, rather than a dystopian, future. This will require business models to be anchored in partnership.
2. It is clear that **the role of data** will be increasingly important. Industry will need to glean better insights on the way assets function, consumers behave and industry competes. Government and the private sector must adapt to the increasing role of data in the infrastructure sectors.
3. The required **workforce skills mix** within the infrastructure sectors is changing as Industry 4.0 reshapes industrial value chains and processes. Grappling with labour market dislocations and upskilling workforces are increasingly urgent agendas for both government and industry.
4. Ensuring **inclusive infrastructure development** in the future will take the combined efforts of government and the private sectors. Infrastructure is the essential foundation for economic and social activities, yet it is not a given that assets will be built and managed in a way that serves society equitably or safeguards the environment.

Better coordination between all players

In order to respond effectively to the analysed trends, we contend that both governments and private firms need to develop business models anchored in partnerships over the longer term, rather than acting transaction by transaction. Without this cooperation, we see little chance that the industry could achieve the fundamental change required to respond to, for example, climate change, or to accelerate the introduction of technology into the ecosystem.

Governments will need to consider how to design flexibility into regulations and contractual models, emphasising outcomes, not just inputs, in the infrastructure sector.[3] Governments will also need to test whether current competition policy, which generally aims to encourage more suppliers in the market and foster price competition at the point of tender, supports or hinders the ability to work together with industry to achieve change over the longer term.

As governments move more toward partnerships, and as technology players become increasingly present in the market, incumbent firms will need to develop business models anchored in strategic partnerships to succeed—for example, between traditional construction firms and technology companies, and between government and business. Rather than trying to build the capability required internally, partnerships will allow firms to be more flexible, and work with different players to access capability and respond to a shifting environment. The players that are best able to enter into and evolve these flexible partnerships are likely to win. Additionally, multinational firms need to consider which partnerships can manage multi-jurisdictional operations, with respect in particular to the issue of intellectual property.

The role of data

The use of large volumes of data to make informed decisions will become a critical source of advantage in the future. The future of asset management, commercial revenue strategies, demand forecasting, public procurement and network planning (to name just a few) will be reshaped through the use of data. Grappling with how to generate, standardise, secure and interpret this data will become critical.

Firms should review what proprietary data they can collate that would give them an advantage. This will require infrastructure firms to think both about data that helps them run their current business better, as well as data platforms that might open new business models which cut across the entire sector.

Governments will need to develop policy frameworks for infrastructure data. These will need to test whether government should take an active role in collecting, managing and providing access to data, or whether to leave this to the private sector. Moreover, regulators need to develop models that protect critical infrastructure assets, such as electricity grids, gas pipelines, ports, and water and telecommunications networks, particularly against the threat of espionage, sabotage, and coercion. Regulators will also have to engage in issues linked with consumer privacy, an agenda far larger than the infrastructure industry alone.

Workforce skills mix

The infrastructure industry is especially exposed to countervailing forces where, on one hand, technology offers significant productivity gains through the replacement of low to semi-skilled labour, while, on the other hand, political incentives continue to position the industry as an important source of employment for low- to semi-skilled workers. Moreover, it is likely that today's infrastructure industry does not have sufficient talent with the necessary skills, or diversity, to meet future needs. Nor does it have the processes to help employees build these capabilities.

Ultimately, the industry must balance greater productivity with acceptable workforce disruption. Government and industry will need to work together to construct a smooth transition path. Industry leaders should develop technology plans and timelines, detailing what technology improvements they plan to introduce, the timeline for them, and what impact this will have on the workforce. Governments should require private companies to develop these plans as part of major tenders, both to encourage productivity improvement and to ensure a managed transition. In addition, government will need to develop systematic plans across the industry for retraining the workforce. Individuals should expect to go in and out of training over the course of their career as the skill requirements evolve.

Inclusive infrastructure development

The infrastructure industry plays a central role in enabling society, from providing access to centres of employment, to opening international markets, through to promoting opportunities for long-term savers to realise their goals. Yet, it is not certain that the benefits of infrastructure will be spread evenly across everyone in society.

Governments should ensure that national infrastructure networks meet inclusivity targets and shift to follow globally accepted environmental, social and governance (ESG) factors.[4] The private sector should embrace foundational ESG practices outlined in the Equator Principles. Given that growing evidence suggests ESG factors may offer long-term investment performance advantages, this is just good business sense. Moreover, the private sector can be the vanguard by pushing the frontier forward by setting clear, stretch targets along each ESG dimension.

03

Developing scenarios for the future

Having assessed the megatrends, we see a set of potential implications for the industry. It is also feasible to project forward and develop possible future scenarios for the industry based on how these trends might play out. In this report, we lay out three possible future scenarios. These scenarios are relatively extreme extrapolations of current trends, but remain plausible. They are designed to foster debate about the type of industry we want to create in the future.

3.1 Using the survey to generate scenarios

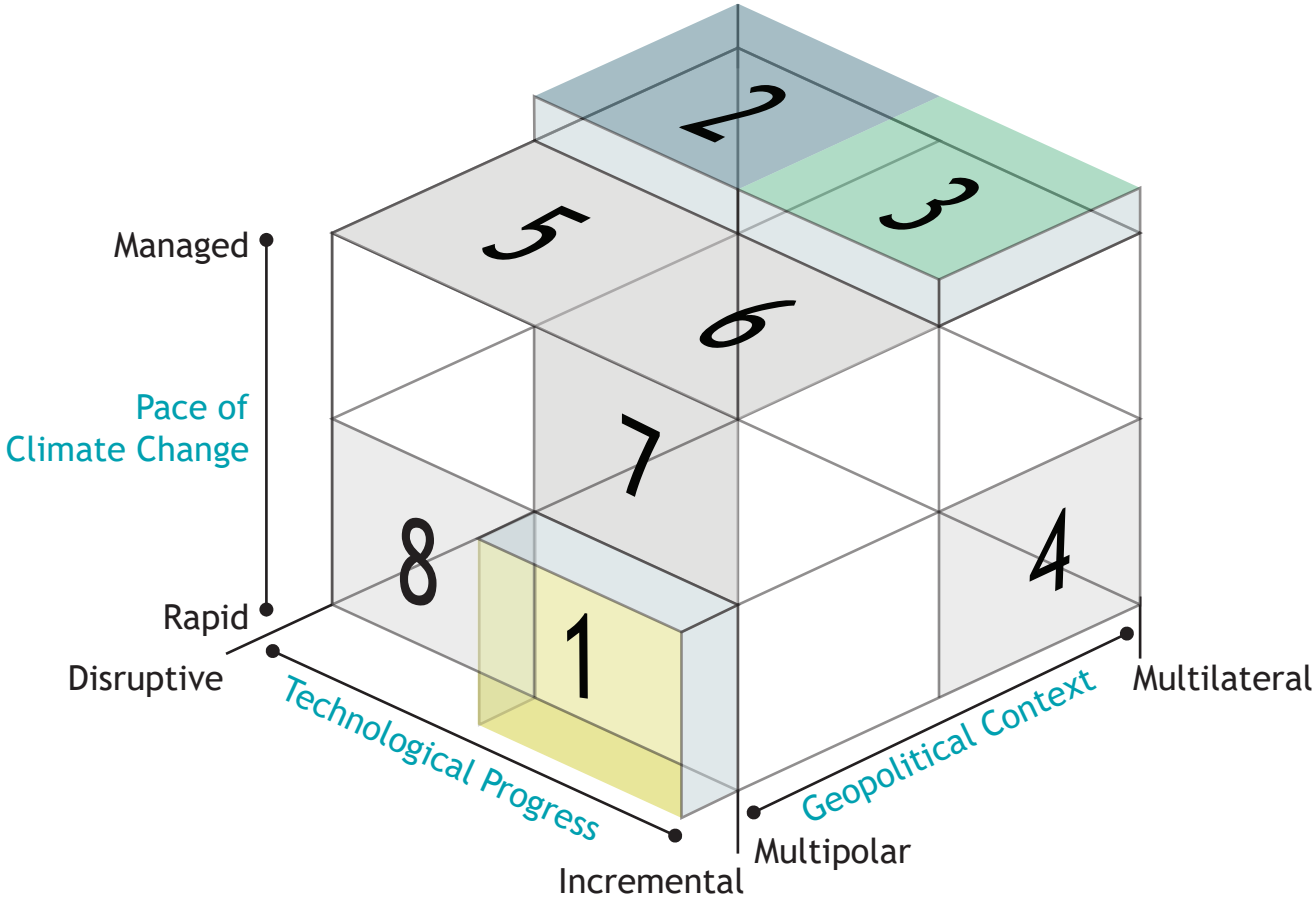
To develop the scenarios, the survey results were combined with expert interviews and discussions, including with the WEF Global Future Council on Infrastructure, to identify three megatrends that respondents see as most determinant of future possibilities.

We started with the megatrends that are high in uncertainty (involving many possible futures), high in potential impact for the infrastructure industry (involving potentially very different futures), and low in preparedness (involving potential future actions and policies that can make a significant difference). The three megatrends that we saw as having the highest potential to shape very different futures are used as determinants to construct scenarios. The three determinants are:

- **Geopolitical context**—Multipolar versus multilateral: The possibility of a multipolar world was seen as driving a wide range of divergent potential futures with very different implications for industry structure and priorities.
- **Pace of climate change**—Managed versus rapid: The set of trends with the lowest preparedness in the survey was the rise of climate change and rise of natural disasters, and resilient infrastructure. The latter category also scored high for impact and was viewed as the highest in risk by survey participants. The survey results were also consistent with the findings of the 2019 WEF Global Risks Report[5].
- **Technological progress**—Incremental versus disruptive: Technology trends, particularly in the emerging world and in the construction and operations sectors, were seen as having the highest potential impact. This is consistent with recent work conducted by the World Economic Forum[6] and the Global Infrastructure Hub,[7] which also highlighted the potential impact of technology across the infrastructure industry.

Having selected these critical megatrends, we then investigated the spectrum of possibility for these trends. With three megatrends selected, each of which has two potential and polar opposite outcomes, we can construct eight unique scenarios for the future. However, many of these eight scenarios are similar. So, from the eight, we selected three unique and quite different scenarios to include in this report. Figure 5 details the logic behind the three selected scenarios.

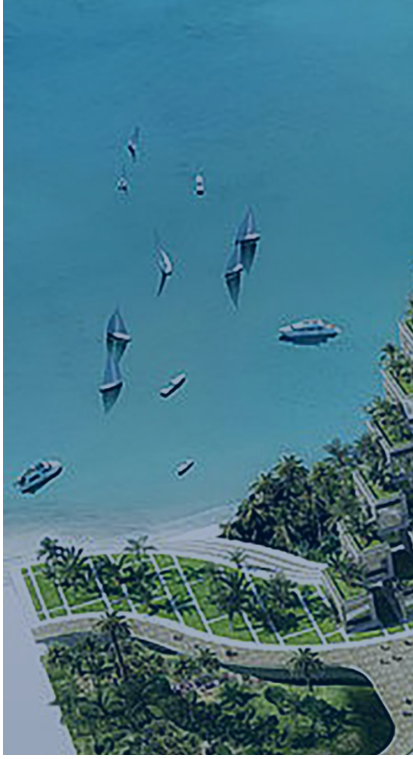
Figure 5: Scenario option space
(with selected scenarios highlighted)



For each of the three selected scenarios, a vision was fleshed out for what the future could resemble, taking some licence on the interpretation of how trends might play out.

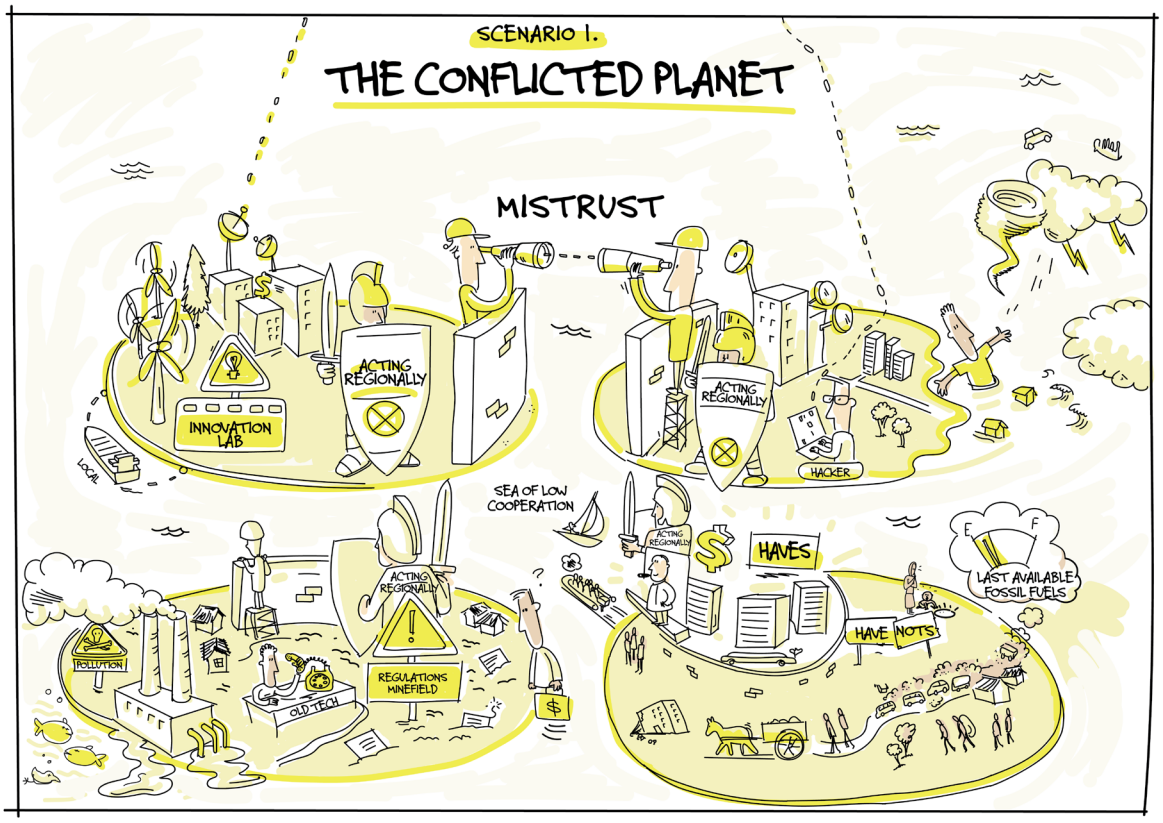
04

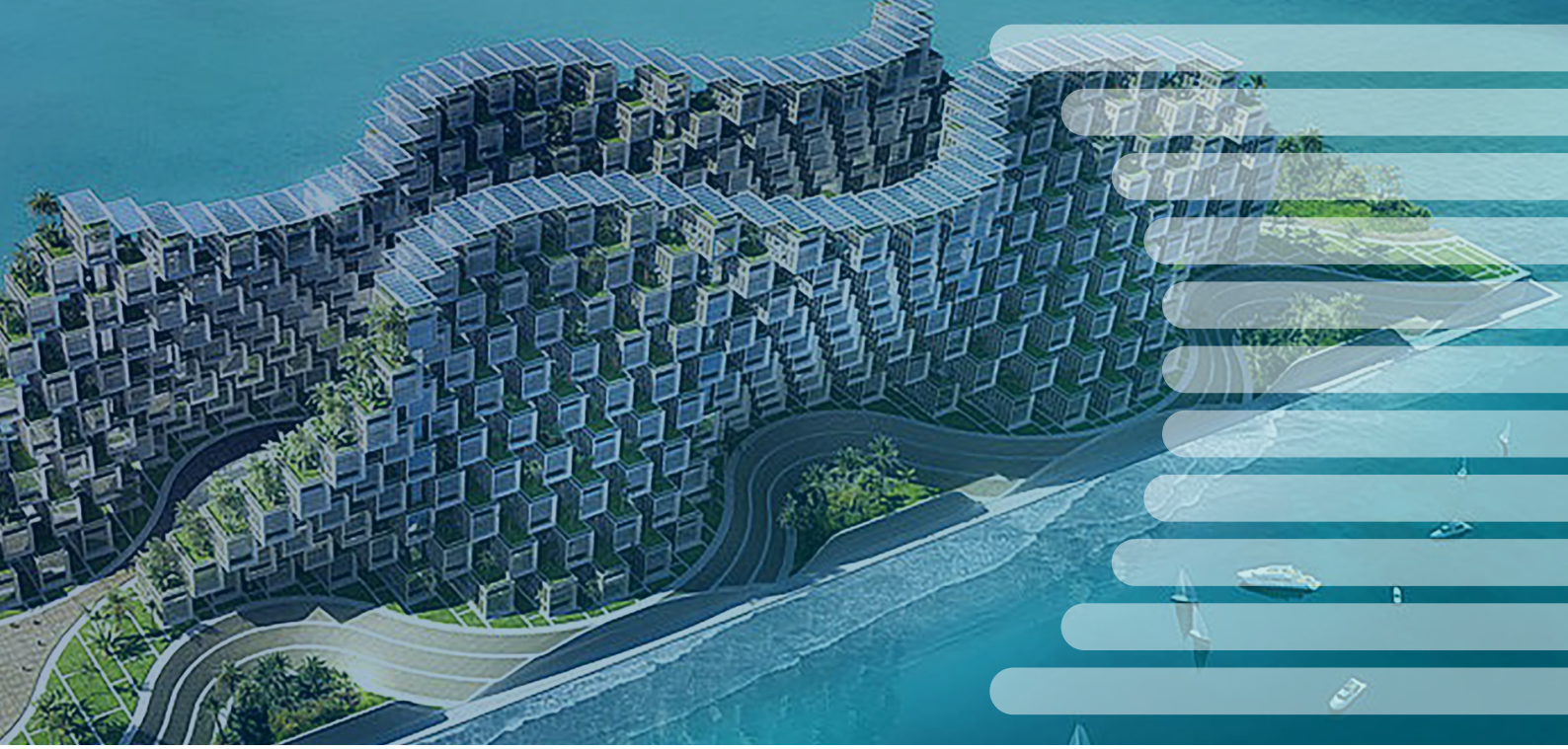
Scenarios and implications for the infrastructure industry



The three scenarios constructed in this report are described below. They offer deliberately extreme, yet plausible, versions of the future. They are not predictions, but are instead designed to prompt debate. We encourage members of the infrastructure community to investigate the potential impacts and implications of these scenarios, and take action to ensure their strategies and plans are resilient to the full range of possible developments.

4.1 Scenario 1 – The Conflicted Planet





4.1.1 Scenario description

Imagine a world where countries, or groups of countries, become increasingly isolated leading to a multipolar(ised) world. The infrastructure industry is dominated by domestic champions that are slow to innovate and slow to adapt to external shifts, such as climate change.

Using the three scenario determinants as a prism, The Conflicted Planet scenario is defined by:

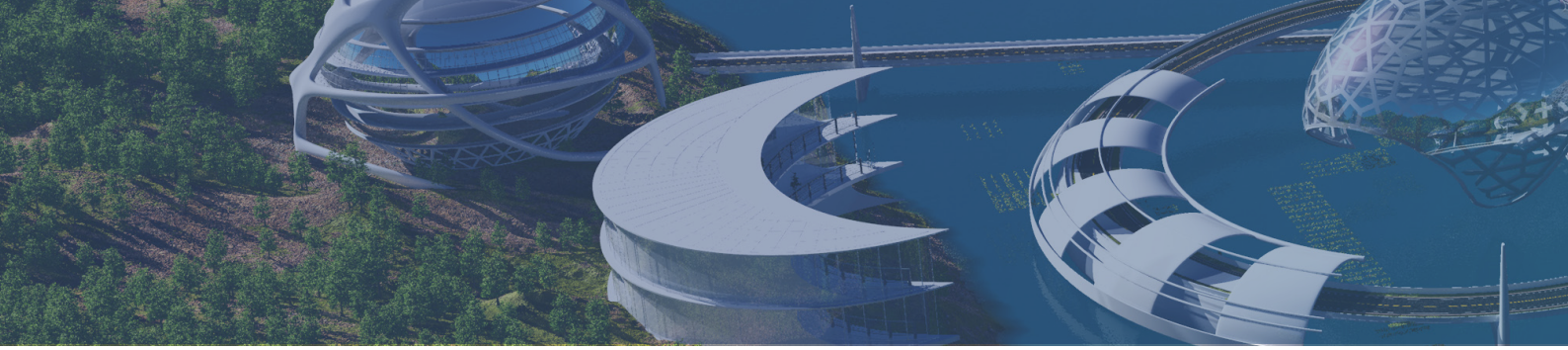
- **Geopolitical context (multipolar)**—Heightened global political competition leads to a reliance on local markets and the formation of regional trade blocs. The infrastructure industry becomes dominated by monopolistic companies with deep connections to government.
- **Pace of climate change (rapid)**—The world moves at multiple speeds to tackle climate change with some regions seeking to mitigate impacts, while others pursue adaptation-based strategies. The infrastructure industry, now increasingly domestic, aligns with domestic climate policy.
- **Technological progress (incremental)**—Incremental development and uptake of new technology hinders productivity growth and climate responsiveness across economies. The infrastructure sectors are acutely impacted as productivity gains lag other sectors.

In The Conflicted Planet scenario, the structure of international cooperation is multipolar and defined by regional allegiances. Geopolitical rivalry shapes all forms of political and economic interactions (domestic and international). Trade becomes politically motivated, rather than following comparative advantage, leading to significant cost inefficiencies in domestic economies. Local economies increasingly rely on local (and regional) factor markets to retain local jobs that might otherwise be lost in a system of open, global trade (for example, a reduction in the offshoring of technology and manufacturing jobs).

Many nations design economic policy to project a strong outward image, resulting in a bias toward monopolistic national champions. These national champions rely on interventionist policies to erect artificial barriers to competition and to provide strategic funding support. In nations where governance norms are not well established, the risk exists that domestic inequality may increase due to the concentration of rents among the beneficiaries of powerful domestic monopolies. On the other hand, nations (and regions) with entrenched governance norms may actually see inequality fall as firms (and governments) increasingly rely on local labour and product markets.

Regionalisation drives local regulatory harmonisation, creating a global economy characterised by a tapestry of regulatory, governance and cooperation systems across regions. Different regions pursue markedly different climate strategies despite the rapid pace of climate change. Some regions take progressive stances by attempting to mitigate climate impacts through incentives programs designed to spark innovation in climate-smart technology, and to transition to renewable power. Other regions are less concerned with climate change, preferring to optimise the economy for short-term growth and employment. The lack of unified climate policy negatively impacts the geographically disadvantaged, and especially the economically disadvantaged in relatively poorer regions, who are highly exposed to the adverse impact of weather-related events. Over time, the shifting climate may increase the number of climate-displaced peoples. [8,9]

The pace of technological progress is incremental. The diffusion of technology is limited with national champions hoarding intellectual property and stymying technological innovations by domestic competitors. Lacklustre technological development, combined with anti-competitive market structures, slows innovation and productivity gains. The general lack of innovation incentives and frequency of state interventions leads to an infrastructure market that relies on public funding streams.



4.1.2 Implications for the infrastructure industry

1. Infrastructure business models shift to focus locally with the emergence of national infrastructure champions

This scenario sees the infrastructure industries shift in orientation and market structure. A once globalised and competitive business becomes domestically oriented and monopolistic (with regulations barriers and public financial support creating artificial barriers to entry). National champions may vertically integrate across sector value chains or scale to the size of large, national holding companies integrating multiple strategic sectors. Given the anti-competitive market structures and limited technological innovation, these champions operate with limited commercial incentives and the political mandate to maximise employment opportunities.

The inherent strength and sophistication of domestic factor markets (labour, capital, technology, building materials) act as fixed constraints on the scale (and capacity) of the national infrastructure champions. Regulatory harmonisation enables firms to compete within regions and, to the extent possible, draw on regional factor markets. It is expected that the relative scarcity of resources encourages coordination within regional blocs, particularly in the water, power generation and building materials sectors.

International infrastructure cooperation (in terms of sharing knowledge, capital and resources) slows despite continued cooperation within some regional blocs. The transnational transport and logistics sectors are the most adversely affected. The reduction in international trade negatively impacts shipping-related industries; shifts patterns of air travel and reduces the attractiveness of air-related assets; and shifts the importance of port-hinterland connections. The travel and logistics industry are constrained by the scale of domestic demand, unless a region establishes a robust trading system, with significant specialisation in last-mile, intra-urban logistics expected.

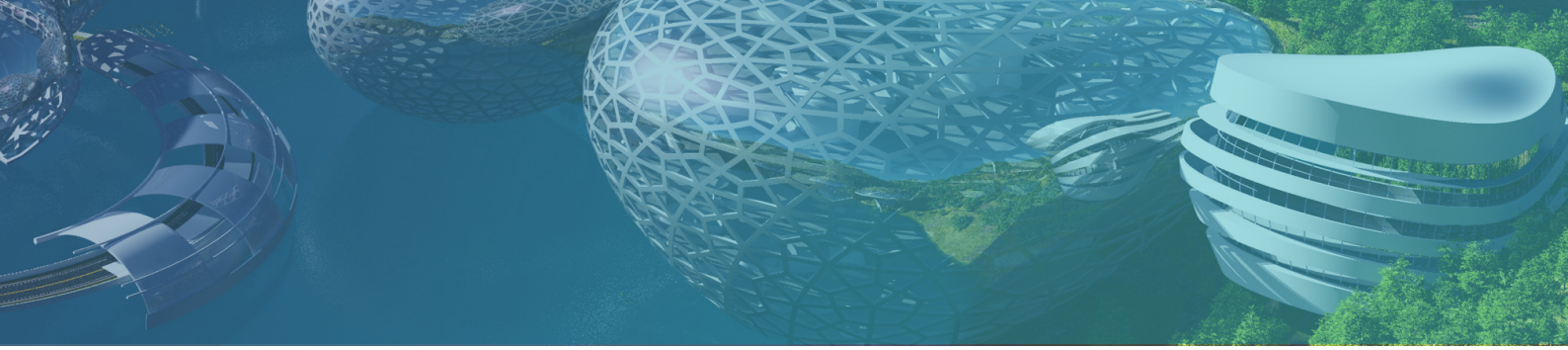
The globalised private and public financial markets for infrastructure reduce in importance. Nations with established savings pools, mature capital markets and sophisticated banking institutions continue to pursue private participation agendas shaped by national champions in the financial and infrastructure industries. The transnational private participation market stalls, however, with limited cross-boundary activity (financial or operational) between regional blocs.

2. National security infrastructure becomes more critical, with a focus on strategic sectors such as energy, water, telecommunications and cybersecurity

In a world where the national strategic interest is paramount, governments invest heavily in sectors viewed as essential for security: energy, water, telecommunications and cybersecurity. Regional blocs are focused on some degree of regulatory alignment to enable formation of regionalised internets that amplify the national interest and limit the flow of information across global regions. Cybersecurity for the telecommunications and energy sectors becomes imperative, in particular the security and ongoing maintenance of data centres or hubs.[10] The scale of investment into social sectors, such as education and healthcare, varies significantly across countries.

Utility sectors and power and water take precedence, with nations attempting to satisfy domestic demand from local factor markets. Vertically integrated national power and water markets are common with power feedstocks and water serving as foundational coordination mechanisms in regional blocs (to overcome domestic resource constraints). Emerging nations with limited resource endowments allow foreign champions to provide basic services from electricity to water and telecommunications, requiring the champions to absorb significant costs related to regulatory alignment, and administrative costs linked to establishing foreign presence.

The fiscal burdens are large to support these strategically essential sectors. The vertical integration of the sectors drives economic inefficiencies exacerbated by highly bureaucratic institutions. The state subsidises basic services to manage domestic inequality.[11]



3. Public infrastructure investment focuses on improving the resilience of the nation's infrastructure stock, revolutionising parts of the industry's value chain

Rapid progression of climate change does not serve to galvanise coordinated global action. Countries and regions pursue divergent strategies with varying degrees of coordination within regional blocs. However, improving the resilience of national infrastructure stocks is a cross-cutting priority. This is likely to have three broad impacts.

First, improving resilience leads to innovations in the building materials sectors. The innovations target materials capable of resisting the intensification of climatic events, or, more likely, process improvements capable of reducing the cost of producing the engineered materials needed to restore asset operations in the case of a severe weather event.

Second, the infrastructure industry is likely to develop more modular ways of constructing and expanding assets in a more climatically volatile world. This agility will enable planners to not only respond after an event, but also to rapidly scale, or retrench, capacity across other parts of the asset networks to manage second- and third-order impacts. Fundamentally, this will mean that the design phase of the project life cycle is commoditised once modular designs are tested and rolled-out, thereby creating significant first-mover advantages for the asset design industry.

Third, the shift to more modular designs, agile network planning and the use of advanced building materials will be complemented by technological innovations. Advanced digital twins covering the full duration of an asset's life (from conceptualisation through operation) and advanced analytics to manage the functioning of critical asset networks are likely to be deployed. These tools will enable planners to forecast impacts on asset networks (including changes in demand) and develop remedial solutions.

These changes may be more muted in emerging markets. Technological diffusion is likely to be limited unless significant concessions are granted on market access, competition, factor market access, and political allegiance. This is likely to create powerful incentives for domestic innovation, provided national champions do not crowd out smaller firms, as emerging nations seek domestic solutions to combat the changing climate.

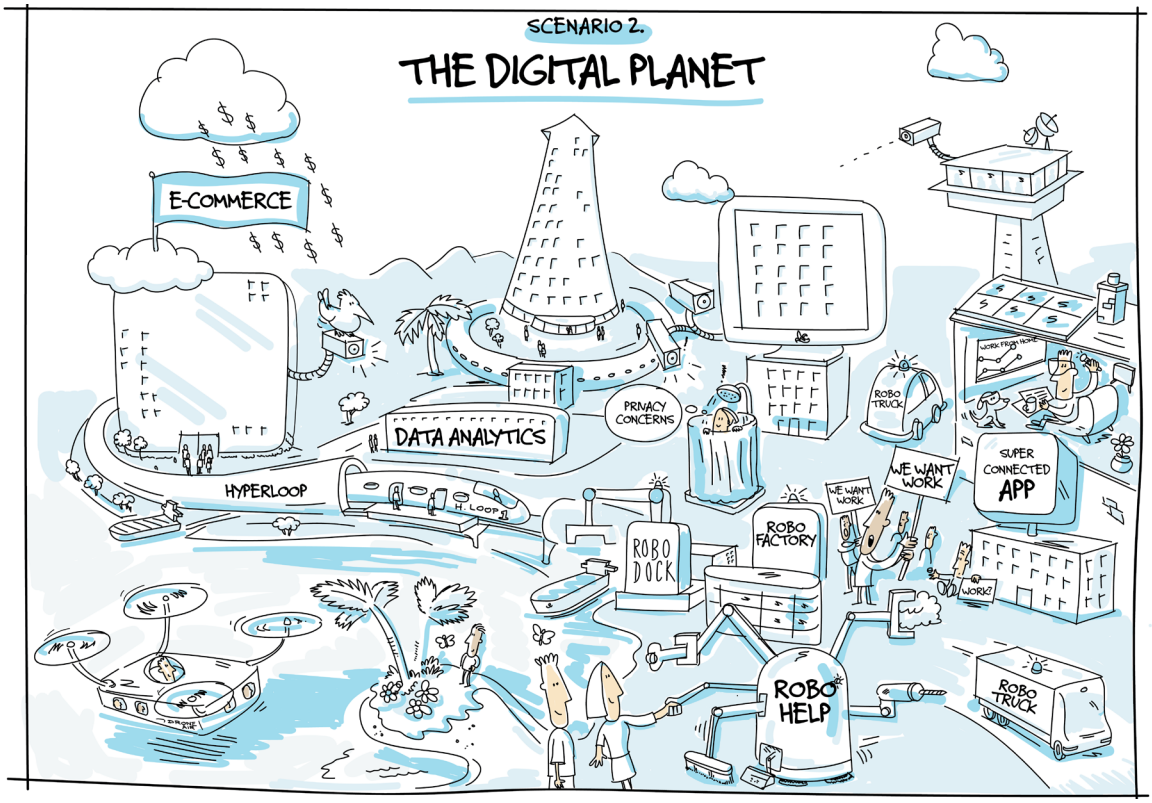
4. Preoccupation with the national interest limits global regulatory coordination and efforts to manage global public goods

The reorientation of the infrastructure industries toward local monopolies (depending on sector and location on the value-chain) reduces the importance of multilateral cooperation. Common practices in project preparation, procurement best practices, shared expectations on construction standards, and sophistication of asset management post-construction either regionalise or dissipate. Global coordinated action against poor governance practices and wasteful spending are also less common as national governments exert 'national interest' narratives over the domestic infrastructure industry.

Environmental legislation, including carbon emission targets and sustainability standards, vary significantly across regions reflecting national (or regional) priorities. Those nations with the financial ability, political alignment and risk exposure improve the resilience of existing infrastructure assets in the face of increasingly frequent and intense natural disasters. While some intra-regional cooperation is expected on environment protection and climate change adaption (and mitigation), the scale is limited to those regions facing the greatest risk from shifts in weather events.

The erosion of multilateral fora to tackle global challenges has second- and third-order impacts on socioeconomic issues, particularly for emerging nations that benefitted from the financing and expertise available from the deceased international financial institutions.

4.2 Scenario 2 – The Digital Planet



4.2.1 Scenario description

Imagine a world transformed by technology where every facet of life is touched by data, analytics and robotics. Technological innovation is rampant, controlled by large companies that have steadily reshaped the infrastructure industry.

Using the three scenario determinants as a prism, The Digital Planet scenario is defined by:

- **Geopolitical context (multilateral)**—Broad-based geopolitical cooperation deepens economic, financial and social connections across countries, with the private sector taking over some of the traditional roles of national governments. The infrastructure industry is led by the private sector with the state stepping back to play a light-touch regulatory role.
- **Pace of climate change (managed)**—Collective responses to climate change are well established with clear adaptation and mitigation actions in place. A combination of global cooperation and technological progress revolutionise the infrastructure industry's responsiveness to climate change, affecting the way services are provided to consumers, as well as the tools, processes and materials used to develop assets.
- **Technological progress (disruptive)**—The infrastructure industry is revolutionised by technology firms capable of planning, delivering and operating vast networks of climate-responsive assets.

In The Digital Planet scenario, the role of government organically reduces as the private sector's influence increases across economic, social and political facets of life. Transformational advances in technology and digitisation enable business models that generate high returns on capital to the owners of technology. The role of government centres on managing and arbitrating tensions within the economy and between industry and society. Specifically, governments safeguard social interests by managing the labour displacements caused by rapid technological advancement; the competitive structure of industrial markets to reduce unnatural monopolies forming; the equitable access to data pools to reduce obstacles to innovations; and the international coordination required to overcome transnational challenges, such as climate change.

Structural discontinuities in labour markets are a natural by-product of rapid and broad-based technological advancement. High-skilled employment (particularly data science, engineering and robotics jobs) and automation have fundamentally displaced more technical crafts and lower-skilled manual occupations. Wealth distribution becomes increasingly skewed to a smaller number of people in high-value, highly skilled jobs. Governments increasingly focus on managing the labour market to ensure sufficient investments are made into training and education to provide citizens with the opportunity to participate in the modern, technologically-driven economy.

With technological innovation hard-wired into the fabric of global society, and barriers to entry low with free access to data, entrepreneurs consistently bring products and service to the market trying to displace incumbent firms. Large incumbent firms buy

out successful start-ups to maintain their market position in the face of fierce competition from other established firms. But this is a continual competitive threat that fosters technological innovation. In emerging markets, the situation is different. A reliance on foreign technology (and technology providers), the lack of deep pools of risk capital, and a smaller pool of graduates with the right technology skills constrain entrepreneurship. While it is less likely that positively reinforcing innovation systems evolve in constrain emerging markets, there may be a higher potential for 'leapfrog' innovations.

Technological progress is disruptive in The Digital Planet scenario. Advances in material science, computer science, data science and robotics power a technological revolution that disrupts industrial, consumer and social markets. The digitisation of real life leads to the creation of digital twins that describe, analyse and predict consumer behaviour and real-life demand patterns enabling real-time adjustments on the supply side of product markets and network industries. Climate change is no longer an issue warranting 'policy space' due to coordinated global action to reduce carbon emissions and the broad-based application of climate-smart technology and building materials.

In this scenario, the nature of the infrastructure industry changes fundamentally. Technology firms reshape the market by replacing or acquiring traditional building materials firms, builders, asset owners and operators, and service providers. Data is the critical currency for the industry's firms as the crucial input to the integrated and comprehensive digital twins that manage asset networks from planning, through construction and operations. The availability of personal data, combined with relatively light-touch privacy regulation, have transformed the user experience across asset classes, enabling deeply personalised services.

4.2.2 Implications for the infrastructure industry

1. Private companies are the primary supplier of infrastructure assets and services with business models reliant on technology and advanced data analytics to improve efficiency and customise services

Private sector participation (and complete ownership) is the dominant vehicle of asset delivery and management. Technology and the insights available from advanced analytics fundamentally alter the industry's economics by lowering the cost base; boosting construction productivity; raising the revenue potential of providing infrastructure-linked services; and broadening opportunities for data monetisation.

Technology companies, in particular, begin to play a leading role in the design and delivery of infrastructure, and control data pools and interfaces. This leads to not only a diversity of new services, but also to an increasingly dominant position for technology companies in the infrastructure industry. Technology players integrate planning, design, construction, and maintenance to control the data and systems used on their projects. Firms outside the emerging common data systems are disadvantaged, because they cannot process data from upstream activities, and the data they produce is less valuable for downstream activities.

Independent contractors and pure operations-and-maintenance companies are most at risk because much of their work is now automated, and they increasingly depend on data from partnerships with design and engineering firms. They are forced to increase integration and collaboration across the value chain, or risk failure.

The dominance of the technology companies has displaced the traditional financial industry. Investment shifts away from physical assets and toward technology that supports step changes in asset productivity, for example the building of advanced traffic management systems that receive much greater throughput on existing transport networks. The industry becomes less capital intensive, there is a surplus of available capital and the role of independent capital providers becomes less important. Large investment houses reduce in size and the investment industry becomes more fragmented with large firms competing with the family offices of the inventors, patent-holders, and founders of the fundamental technology architecture to fund the next technology innovation. Infrastructure investments have become routine corporate functions, rather than a niche asset class in the private markets.

2. Infrastructure asset demand shifts, lowering physical asset needs significantly, while boosting demand for telecommunication-linked assets

In this technology-dominated scenario, the physical world is complemented by a rich virtual world offering immersive, productive and affordable platforms to optimise physical systems. As a result, people can travel further, more easily. The value of proximity to major economic centres reduces, leading to fundamental changes in land markets, urban design, transport networks and telecommunications requirements.

Demand is now intensely local, reshaping transport markets with significant reductions in the capacity and coverage of road networks and retrenchment of rail capacity. These traditional transport modes are replaced by affordable autonomous, shareable and electric vehicles providing last-mile intra-urban solutions.

Energy requirements in The Digital Planet scenario are significant. However, technological breakthroughs in renewable power generation, smart grid management and storage enable countries to meet the demands of consumers and industry sustainably. Improvements in the efficiency with which industrial and consumer machines use power has also improved, lowering total energy demand systematically. Global cooperation leads to the diffusion of these energy-producing and efficiency-enhancing

technologies across countries, including between emerging and mature markets.

With the rapid pace of technology development and economic reliance on data, this scenario sees significant evolution in telecommunications and data infrastructure. There is large-scale investment in global networks to underpin global communications. Data centres are critical nodes in commercial infrastructure networks. Their physical security becomes a more acute issue given the disruptive impact of any data breaches.

3. Infrastructure value chains are dominated by InfraTech

InfraTech becomes the dominant theme, with firms looking to replace manual activity with data-driven solutions at all steps of the infrastructure value chain. Technology products replace traditional manual jobs and trades (see next section for labour market implications). The human element is, however, not fully replaced as highly skilled technical experts in data science, robotics, AI, and materials science oversee the sophisticated InfraTech networks.

The advanced data and analytics capabilities within the InfraTech ecosystem enable agile and highly detailed real-time mapping, analysing and predicting of network performance. Advanced AI-based systems are used to forecast network demand in the development and planning of every infrastructure asset. Predictive modelling is used to forecast potential consumer interactions across the asset, based on detailed datasets tracking consumer purchases, movements and habits, and enabling firms to maximise opportunities to cross-sell products (or to monetise the insight from the predictive model). These models, additionally, inform future network investments whose design, construction and operation are governed by sophisticated eight-dimensional (8D) building information models (BIM).

In this scenario, the way assets are built is fundamentally different, resulting in productivity gains, ability to deliver on-budget, and speed. These 8D BIM are the nervous system of the construction phase by fully integrating data across the full asset life cycle: object data (3D); scheduling (4D); operating and capital expenditures (5D); sustainability (6D); social inclusiveness (7D); and operation and maintenance (8D). While the core construction activities are handled by autonomous robots and equipment, human workers supervise projects and manage the real-time building materials inventory systems.

Technology also boosts transparency during the procurement process, with bid models automatically predicting outturn prices using vast datasets of final prices from previous procurements (or asset deliveries). The universality and accuracy of the systems encourage firms to continually innovate and deliver quickly, below budget and on-spec since the blockchain-powered procurement systems are ubiquitous. Moreover, the transparency afforded by these advanced technologies promote scrutiny by stakeholders.

The operations and maintenance (O&M) functions of assets – be they economic, social or civic assets – are largely commoditised. Sensors built into an asset during construction stream information into the asset's BIM to guide facility management activities. While the 8D models have internalised most O&M functions, specialised firms exist to create and manage digital twins that optimise asset operations and predict potential maintenance activities ahead of the 8D BIM. Moreover, industrial robotics firms maintain onsite robots.

4. Concentrated economic and political influence leads to workforce dislocation with minimal efforts to address systematic imbalances

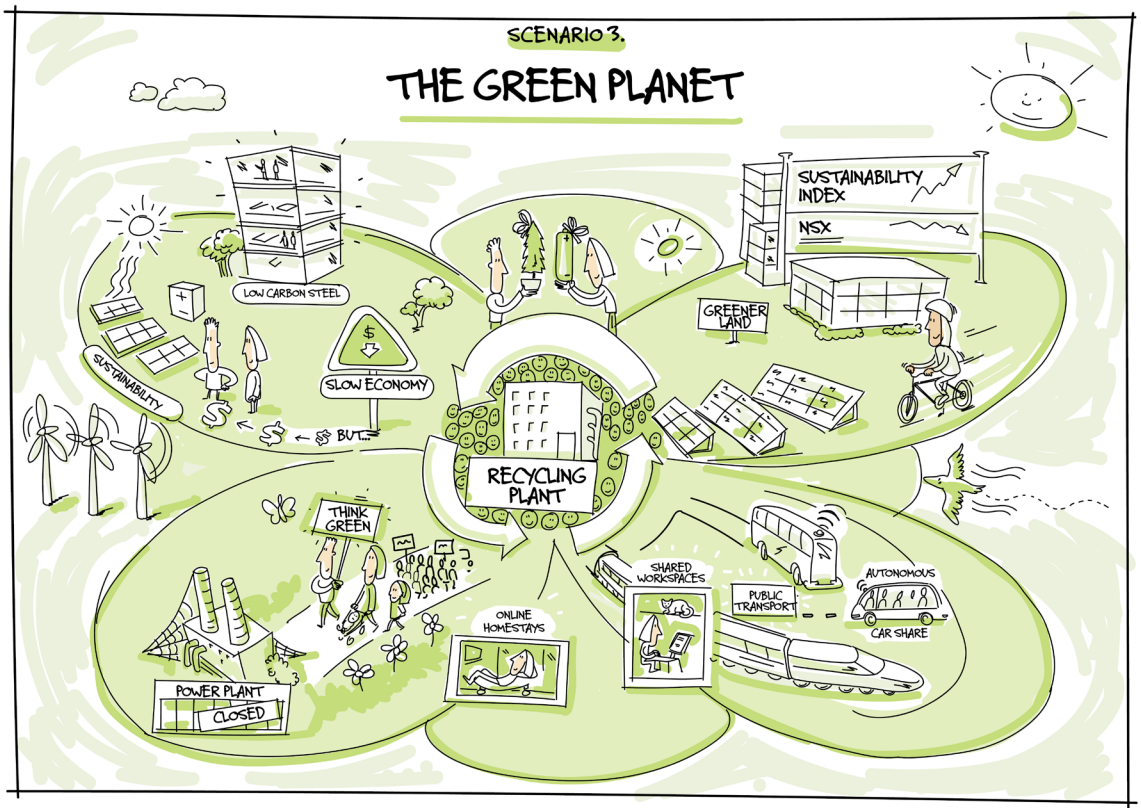
In The Digital Planet scenario, technology permeates every aspect of life. The impact is felt acutely in the labour markets servicing the infrastructure industry where labour is, largely, displaced by InfraTech, which aligns with current projections that by 2050 more than 40% of today's jobs could be obsolete,[12] and hundreds of millions of jobs lost to automation.

While the role of government is reduced in The Digital Planet scenario, public policy initiatives capable of re-skilling labour forces are paramount. This is essential to ensuring that with seismic gains in productivity, speed, consumerisation and quality, the infrastructure industries support more than just an elite workforce. The workers requiring support from the state do not have a universal background, but are rather impacted differentially based on market (emerging versus mature), sector, age group, gender, educational level, and socio-economic background.[13]

The interactions between labour, private firms and government are particularly fractious in emerging markets. In nations with less entrenched norms toward equitable distribution of opportunity, decision-making and wealth, the interactions lead to extractive institutional structures, largely favouring foreign technology firms and their corporate tributaries in offshore markets. Where such norms are more established, the relationship may be less extractive as the incumbent firms will be required to support local employment.

The political and market dominance of the private sector raises the prospect of base erosion and profit shifting (BEPS)[14] in this scenario, especially in emerging markets. Governments are not able to enforce taxation legislation (or restrain private lobbies from influencing sympathetic legislative amendments) enabling the dominant firms to privatise value creation in the economy. This situation is likely to be exacerbated in emerging nations.

4.3 Scenario 3 – The Green Planet



4.3.1 Scenario description

Imagine a world where the health of the environment and wellbeing of citizens are paramount in economic, social and political decision-making. The infrastructure industry revolutionises, following the principles of the circular economy.

Using the three scenario determinants as a prism, The Green Planet scenario is defined by:

- **Geopolitical context (multilateral)**—Comprehensive cooperation ensures geopolitical alignment on global public goods, such as climate change and income equity, and manages an ever-deepening system of economic, financial and social integration. The infrastructure industry is global, with private firms working in partnership with a strong state.
- **Pace of climate change (managed)**—Mitigating further climate impact outweighs other decision metrics. A combination of global cooperation and technological progress revolutionises the infrastructure industry with a focus on prioritising the 'greenest' technology possible.
- **Technological progress (incremental)**—Technological innovation is focused on enhancing the circular economy and lowering environmental impact of economic activity. The infrastructure industry sacrifices productivity gains for a lighter environmental footprint despite clear potential from less 'green' technology.

In The Green Planet scenario, environmental caretaking becomes the primary determinant of social and economic value, driving policy decisions for governments around the world. Safeguarding the world's environmental and climatic systems is a powerful coordination mechanism that drives sustained global collective action. The impact of global cooperation is considerable, with significant advancements in the climate mitigation agenda as advanced technologies are deliberately commoditised to enable emerging world economies' use. Additionally, consumers take up the challenge of reorienting the demand for goods to more sustainable products and production processes (such as the 'sharing economy') that reshapes global food production and processing.

Global trade has slowed as consumer demand shifts to domestically produced goods and services. Productivity gains run at a lower rate as public funding concentrates on the development of climate-smart technologies, processes and materials. Moreover, governments broaden sustainability principles to include wealth equity, which is achieved through stronger enforcement of taxation policies (of corporates and individuals) and clamping down on any form of BEPS.[15]

In this scenario, the role of the state is paramount. Economic incentives are recast in many economies by more agile (and globally harmonised) taxation systems and the focus on improving economic, environmental and social equity. These three principles become the rallying point for a system of international cooperation and, in particular, for international organisations that, despite dampened economic prospects in many countries, pursue developmental programs around the world.

Global governance embraces the notion of creating an equal, sustainable and vibrant international community. Global governance architecture is critical as not all regions of the world are fully able to mitigate the impacts of a changing climate, especially across emerging markets. Adaptation strategies are needed to safeguard the livelihoods of people living in the most climate-affected regions, particularly the small states with constrained fiscal and technological resources. Global assistance is required to construct resilient infrastructure, such as sea walls, and for programmatic support, such as long-term supplies of potable water. This support is viewed as a globally emblematic program for social equity between emerging and mature markets.

The Green Planet scenario evolves from stigmatising the infrastructure (and mobility) industry to championing its transition to environmental neutrality. Heavy public investment in the research and development of climate-responsive building materials, low- to no-emitting construction machinery, electrified transportation (linked to renewable generation sources), and iron-clad efficiency regulations have transformed the industry. Profit pools shift to the building materials sector, which continues to develop innovative building materials that are climate-smart, environmentally sustainable and legally mandated for use.

4.3.2 Implications for the infrastructure industry

1. Circular economic policy fosters new business models focusing on environmental services, the sharing economy, and recycling of local materials

In this scenario, infrastructure business models are designed to adhere to the regulatory regimes underpinning the circular economy. The shift in social values and in government regulation promotes opportunities for service-oriented businesses, such as environmental planning for decommissioning and environmental impact auditing. Significant opportunities also emerge in sharing platforms (transport, housing, and equipment, for example) and in recycling building materials. Fiscal policy promotes the use of locally-sourced recycled materials and serves as the basis for new, local enterprises created to recycle building materials.

Design and engineering firms provide experience and capabilities in up-front comprehensive analyses of an asset's environmental impact over the course of its lifetime. Environmental auditing is now a legal requirement for every asset, not only in major mature markets but also in emerging economies, and assessing opportunities to reuse an asset at the end of its life cycle becomes a lucrative business.

2. The focus on sustainability reduces demand for built assets and infrastructure, while promoting renewable energy assets and recycling

Demand for infrastructure changes through a combination of shifts in consumer preferences and regulations. Consumers live intensely local lifestyles with the lowest possible carbon footprint. They avoid private transportation, preferring shared and electric options, while regulations have outlawed any form of transportation or energy generation driven by fossil fuels. Network industries have, therefore, changed with mass reductions in the capacity within the inter-city road network and the power sector is dominated by green technology companies capable of both developing utility-scale renewable projects, as well as installing micro-grids (and off-grid solutions) for specific communities.

Cities use sophisticated technology to overcome intra-city congestion by deploying real-time traffic optimisation software and comprehensive infrastructure asset pricing models that charge consumers dynamically fotr use of transportation networks, be they public or private.[16] Many cities have passed regulation banning vehicles from the urban core, encouraging citizens to use other mobility options from electrified bicycles to scooters and mopeds. Urban planners prioritise green spaces, often constructed on or around decommissioned assets in order to revitalise previously unused portions of the city.

3. The infrastructure industry shifts to sustainable technologies, inclusive practices and methodologies across the full asset life cycle

Energy demand continues to grow, as does the demand for recycling infrastructure. Renewable sources dominate energy generation, such as solar, wind, and wave energy, and investments in these assets rise. Extensive networks of 'prosumers' (consumers who are also involved in producing goods) generate their own energy and sell it back to the grid at scale; similarly, they recycle their water and sell the excess. This generates competition across infrastructure markets, which were previously dominated by natural monopoly providers and also creates scale for innovative technologies. Waste policy is shaped by the circular economy and compulsory waste separation is in force across the world. Infrastructure assets, such as wastewater treatment plants and waste-to-energy plants, are ubiquitous.

The Green Planet scenario sees the infrastructure development process evolve significantly around the principle of how to plan, design, build, operate and decommission assets in the cleanest, greenest and most socially responsible manner. InfraTech is deployed to limit negative environmental impact, rather than to boost productivity, which has become a secondary requirement. Productivity losses are exacerbated by labour policies enshrining a 'right to work'.

At the asset planning and design stages, regulation requires developers to run complex simulations that estimate an asset's potential environmental impact over its lifetime. These simulations take into account the construction impact of the asset, and the carbon-intensity of its operations and decommissioning. This estimate is audited by government against strict qualifying criteria before an environmental licence to build or operate is issued. Additionally, adaptive capacity for infrastructure assets must be incorporated at the design stage. Designs must be submitted for climate-robustness assessments to gauge longevity, and prioritise resilience and adaptability. Furthermore, developers are also legally required to conduct thorough stakeholder engagement activities to ensure that disadvantaged groups can have their say and that there is a more equal distribution of the benefits.

During the construction phase, technologies are employed onsite to reduce the environmental impact of the construction process. For example, AI-powered 3D printing creates building elements onsite to minimise transportation impacts and the chance of offsite contamination. Breakthroughs in material science focus on regenerative materials[17] to increase an asset's durability and reduce maintenance costs—for instance, asphalt that resets itself through induction heating, concrete mixed with living bacterial aggregates that can patch up cracks, and new alloys with self-healing properties.

Once operations commence, the regulatory role of the state is significant. Data and analytics from the real-time operations of the asset are fed to environmental enforcement agencies that ensure the asset's environmental impact remains within acceptable limits. Sustainability agencies verify that each asset's environmental impact during and after construction matches projections created by design-stage simulations. Penalties and reputational damage are severe, turning asset management into a highly specialised field.

4. Government policy discourages greenfield projects, and regulates brownfield projects heavily

The Green Planet scenario is, in part, a product of the state's strength to incentivise private investment and consumption into goods and services that are environmentally sustainable. Supported by broad-based global cooperation, governments implement policies that encourage asset optimisation and preservation over new builds.

Existing assets are kept operating as long as possible, requiring significant retrofits and maintenance work to extend useful lives. Governments provide ring-fenced funding and tax incentives to investors to encourage a focus on existing assets in what is termed 'smart growth policy'. As part of this, land use policies focus on increasing densification to reduce carbon footprint. Governments assume the risk of obsolescence by subsidising investment to prolong the useful life of assets that face potential disruption from technological advances (for assets that still meet stringent environmental conditions).

Greenfield projects are rare, especially in mature economies. Proposals for greenfield projects must pass stringent environmental criteria as well as lengthy stakeholder engagement processes that, in part, must prove the asset's contribution to the national strategy for climate mitigation or resilience. Global coordination enables emerging markets to invest in the new assets required to mature the domestic infrastructure stock to meet industrial and consumer demand.

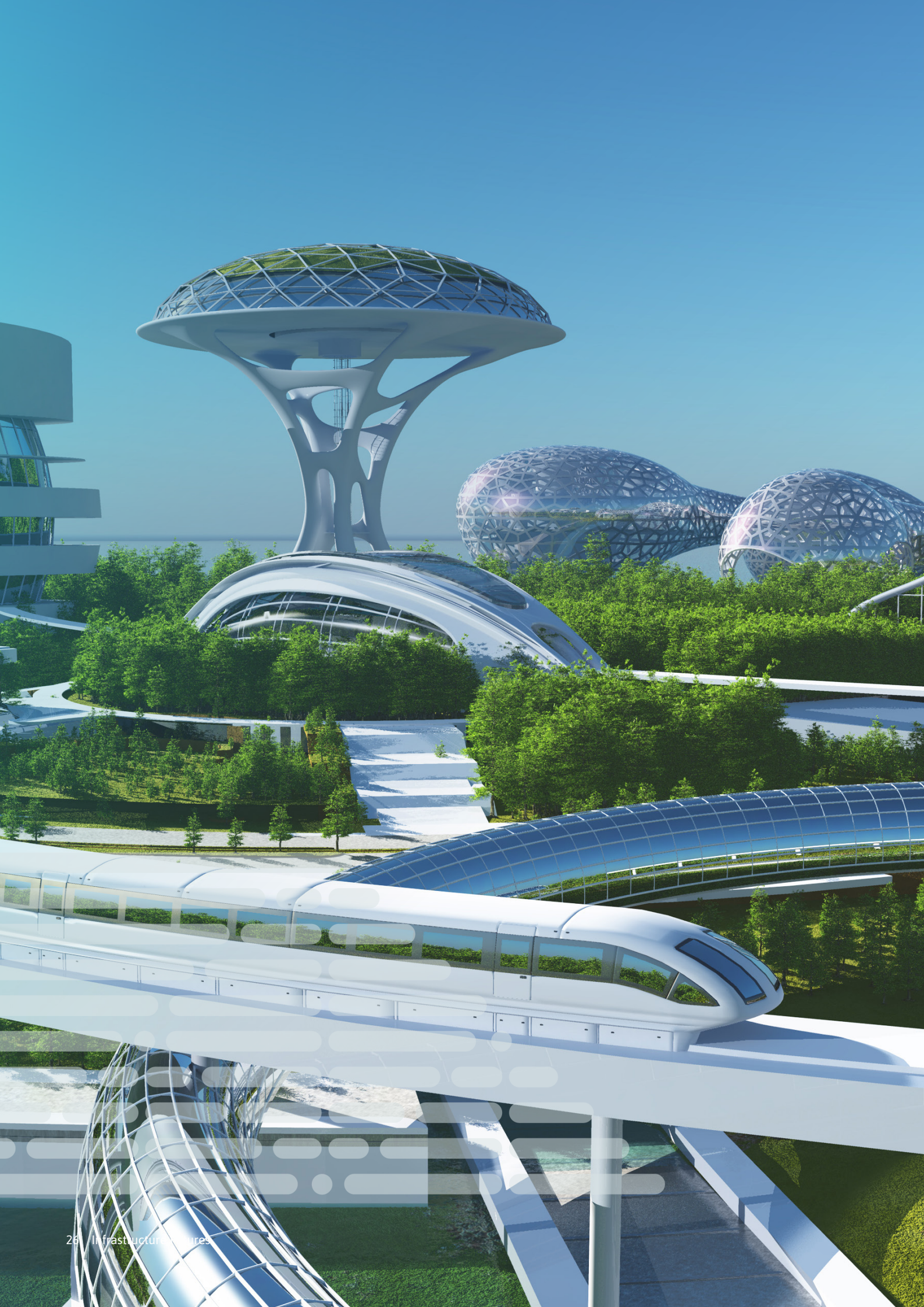
05

The way forward

We encourage members of the infrastructure community to investigate potential impacts and implications in these scenarios and take action to ensure their strategies and plans are resilient to the full range of possible developments. It could also be worthwhile for stakeholders to consider their own ideal scenario at a local level, and what actions would be required to increase the likelihood of achieving this outcome.

For the next steps, the Global Infrastructure Hub and the World Economic Forum encourage interested organisations within the industry, as well as governments around the world, to reach out to us and collaborate on deep-dive analyses on the potential implications of these future scenarios, as well as possible strategic responses.

Our hope is that this report is not a final product, but instead is the start of a process of debate about the future of the infrastructure industry within, and across, industry, the public sector, and international organisations and fora, such as the G20.



Appendix 1:
Details on megatrends

Society and workforce

1. Urbanisation and population growth

Rising population and the disparity of opportunity between rural and urban areas have led to a worldwide migration to urban areas, fostering new clusters of urban economies, large infrastructure investments, and new challenges from overcrowding and congestion. Much of the emerging infrastructure and planning will revolve around the needs of megacities and tier 2/tier 3 cities that are springing up globally.

2. Ageing population and workforce

In the mature world, the proportion of the population over age 65 is steadily increasing as life expectancy lengthens. Ageing workers and fierce competition for talent from other industries have resulted in an infrastructure workforce shortfall, which risks increasing costs and delaying project completion times.

3. Environmental, social, and governance/corporate social responsibility

There is growing evidence that suggests environmental, social, and governance (ESG) criteria, when integrated into investment analysis and portfolio structure, may offer investors long-term performance advantages. Awareness of ESG and CSR has been growing as stakeholders pressure companies for accountability and recognise companies for sustainable practices.

4. Sharing economy

The sharing economy refers to the ecosystem built around the sharing of human and physical resources including shared creation, production, distribution, trade, and consumption of goods and services (e.g. ride sharing, space sharing, job sharing, etc.)

5. Pressure for companies to increase efficiency and productivity

Increases in efficiency and productivity have been a critical part of global economic growth and improving standards of living. National productivity growth stems from an interaction of technological change, organisational change, industry restrucuring, resource reallocation, economies of scale, and scope

6. Rise of health and safety concerns

Civil engineers have raised safety concerns around ageing and inadequate global infrastructure (e.g. structurally deficient bridges, inferior roads and rail lines, ageing systems for drinking water and wastewater). These pose a threat to human health and safety, and also can cost billions in lost productivity. Such concerns call for innovative investments and plans in support of safer, sustainable, more reliable infrastructure networks, and establishing procurement resilience.

Market and customers

7. Demand shift to emerging economies

China has become the world's leading destination for foreign direct investment (FDI), a global manufacturing hub, and is currently engaging in the Belt and Road Initiative, its global development strategy involving infrastructure development and investments in 152 countries and international organisations across the globe. Other rapidly developing economies (RDEs) are working to build similar success stories, resulting in rising demand for infrastructure to support their meteoric growth.

8. Infrastructure financing gap

Despite the widely agreed-upon sentiment that infrastructure is an enormous economic multiplier, the world is facing a $15 trillion gap between projected investment and the amount needed to provide adequate global infrastructure by 2040. This financing gap is linked to issues ranging from corruption, to overbearing bureaucracy, and growing workforce shortages.

9. Increase in bigger, more complex projects

In recent years there has been a rise of multi-billion dollar infrastructure projects, also known as megaprojects. As projects increase in size and complexity, they become inherently riskier. Stakeholders can expect issues stemming from the need for international cooperation, politicisation of megaprojects, and capacity constraints in the face of successful project completion.

10. Private participation in infrastructure

Historically, governments were the exclusive providers of a nation's infrastructure. Over time, and because of the global financial crisis, lower tax revenues, and higher expenditure, governments are increasingly relying on the private sector to help fund these investments.

11. Globalisation and international trade

Globalisation refers to the growing interdependence of the world's economies, cultures, and populations, brought about by cross-border trade in goods and services, as well as flows of capital, people, and information. International trade, enabled by infrastructure of all types, drives the global economy, allowing countries to expand their markets for both goods and services that otherwise may not have been available or affordable domestically.

Geopolitics and regulation

12. Global divide and increased social inequality

Global divide refers to the widening gaps in wealth, digital access, education, and even health outcomes within and between countries. In recent years, the gap between the rich and everyone else has increased markedly in nearly all countries. Such economic inequality can result in health and educational disparities among populations, which in turn cause a host of social and economic problems.

13. Multipolar world

Polarity in international relations involves the complexity of governmental power and its distribution within and across the international system. The historical dominance of the G7 states has been challenged by emerging economies and powerful coalitions, giving rise to a multipolar world.

14. Rise of distrust and pressure for increased transparency

Stakeholders are more concerned than ever with an organisation's reputation. Trust is becoming harder to obtain and retain, becoming an indispensable currency to maintain good relations with a wider array of stakeholders.

Technology

15. Rise of new materials and substances

Researchers have created a range of new advanced materials, which are key building blocks for future devices and systems, and typically have properties that are superior to and outperform conventional materials (such as geo-synthetics, reinforced polymer composites and advanced polymers, nanocellulose, and wood-based composites). The development of advanced materials may lead to the design of completely new and remarkably resilient infrastructure.

16. Rise of green energy sources

Concerns about volatile prices, potential scarcity of fossil fuels, and environmental issues have led to growing interest in alternative energy sources. Alternative energy sources include new renewable fuels like biofuels or biomass along with power production from renewable sources like wind, hydro, solar, or wave power.

17. Rise of internet of things, sensors and smart infrastructure

As the price and size of sensors and chips drop, they will be placed in a wider range of objects creating smart buildings, smart appliances, the smart grid, smart vehicles, smart packaging, and smart logistics, among other applications. Many companies are working to bring smart products to consumers worldwide, for example, self-driving cars have already driven more than 7 million kilometres on real-world roads and millions more virtually.

18. Rise of artificial intelligence and automation

Artificial intelligence (AI) and machine learning are forms of 'intelligence' demonstrated by machines. This includes human speech recognition (e.g. Siri), competing in a strategic game (e.g. IBM Watson winning at Jeopardy), and interpreting complex data, among many other applications. AI techniques and applications have advanced rapidly with the rise in computer power, access to large amounts of data, and an increased role for autonomous robotics.

19. Autonomous driving and new transport modes

An autonomous vehicle (AV) can sense its environment and navigate without human input. AVs are a natural evolution of the use of intelligent transportation systems including adaptive cruise control, collision avoidance systems, navigation assistance, and semi-automated parallel parking. The rise of AVs is coinciding with and facilitating the emergence of disruptive new mobility models based on autonomy, sharing, and electric vehicles.

20. Digitisation (BIM, onsite collaboration apps)

Digitisation refers to an organisation's leveraging of digital technology to better connect people, processes and ideas, thereby more precisely addressing particular needs. For example, building information modelling (BIM) is an intelligent 3D modelling process that gives architecture, engineering and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct and manage buildings and infrastructure.

Sustainability and resilience

21. Ageing infrastructure

Ageing and outdated infrastructure is a global issue resulting from gaps in spending on new infrastructure and maintenance. This widespread problem impacts the effectiveness of transportation networks, water systems, communications networks, and the energy grid. Associated risks with the potential failure of critical infrastructure are wide-ranging in nature, from social, economic, health and safety, and environmental.

22. Rise of natural disasters and resilient infrastructure

Natural disasters are the consequence of a natural hazard (e.g. volcanic eruption, earthquake, landslide, flood, wildfire) that affects human activities. Large growth in areas prone to natural disasters (e.g. coastal areas, fire-prone forests, steep mountain slopes, and riverbanks), increase the number of people affected, as well as social and economic disruption from their impacts. Given the rising incidence of natural disasters, leaders must now track risks and develop resilient infrastructure and deploy rapid response capabilities.

23. Rise of climate change

Climate change refers to a broad range of global phenomena brought about mainly by the burning of fossil fuels that add heat-trapping gases to the atmosphere, resulting in fluctuation of regional or global average temperature, humidity and rainfall patterns over the long-term. Observed impacts include extreme temperatures, rising sea levels, global ice mass loss and rising incidence of extreme weather.

24. Resource scarcity and rise of the circular economy

Resource scarcity is defined as a reduction in economic well-being due to a decline in the quality, availability or productivity of natural resources. Rising population, economic growth and climate change place increasing stress on natural resources such as fossil fuels and minerals, as well as water and arable land. A circular economy is an alternative to a traditional linear economy (i.e. make, use, dispose). Based on the principles of designing out waste and pollution, resources are kept in use for as long as possible in order to extract their maximum value. The goal is to recover and regenerate products and materials at the end of each service life.

25. Rise of security risk

The rise of global terrorism, the vulnerability of the internet, and new perceived harm from physical and cyberattacks on critical infrastructure are bringing about a renewed awareness of risk, as well as new opportunities for those able to reduce it.

Figure A1: Ranked list of megatrends
Megatrends - ranked by average response to each question

	Lowest		Highest		Lowest	
	Certainty of direction	Average (1-5)	Impact to industry	Average (1-5)	Preparedness to handle	Average (1-5)
1	Sharing economy	2.73	Urbanisation and population growth	3.66	Rise of climate change	1.97
2	Globalisation and international trade	2.95	Ageing infrastructure	3.52	Rise of natural disasters and resilient infrastructure	2.03
3	Rise of bigger, more complex projects	3.01	Rise of green energy sources	3.5	Global divide and increased social inequality	2.03
4	ESG/Corporate social responsibility	3.04	Rise of natural disasters and resilient infrastructure	3.48	Resource scarcity and rise of circular economy	2.11
5	Multipolar world	3.08	Rise of climate change	3.46	Rise of distrust and pressure for increased transparency	2.17
6	Rise of health and safety concerns	3.09	Rise of IoT, sensors and smart infrastructure	3.45	Multipolar world	2.19
7	Global divide and increased social inequality	3.09	Infrastructure financing gap	3.4	Autonomous driving and new transport modes	2.22
8	Rise of security risk	3.11	Demand shift to emerging economies	3.33	Ageing population and workforce	2.23
9	Resource scarcity and rise of circular economy	3.14	Rise of AI and automation	3.32	Sharing economy	2.24
10	Autonomous driving and new transport modes	3.17	Private participation in infrastructure	3.25	Ageing infrastructure	2.24
11	Demand shift to emerging economies	3.21	Autonomous driving and new transport modes	3.24	Rise of security risk	2.25
12	Private participation in infrastructure	3.22	Digitisation (BIM, on-site collaboration apps)	3.23	Rise of AI and automation	2.25
13	Rise of new materials and substances	3.24	Rise of new materials and substances	3.17	Infrastructure financing gap	2.36
14	Infrastructure financing gap	3.24	Rise of bigger, more complex projects	3.14	Urbanisation and population growth	2.4
15	Rise of distrust and pressure for increased transparency	3.26	Pressure for companies to increase efficiency and productivity	3.07	ESG/Corporate social responsibility	2.45
16	Pressure for companies to increase efficiency and productivity	3.31	Ageing population and workforce	3.05	Demand shift to emerging economies	2.5
17	Rise of natural disasters and resilient infrastructure	3.31	Resource scarcity and rise of circular economy	2.99	Rise of new materials and substances	2.53
18	Rise of AI and automation	3.42	Globalisation and international trade	2.97	Rise of bigger, more complex projects	2.54
19	Rise of climate change	3.45	Rise of security risk	2.96	Rise of IoT, sensors and smart infrastructure	2.55
20	Ageing population and workforce	3.46	Rise of health and safety concerns	2.93	Rise of health and safety concerns	2.6
21	Digitisation (BIM, on-site collaboration apps)	3.47	ESG/corporate social responsibility	2.86	Digitisation (BIM, on-site collaboration apps)	2.64
22	Rise of green energy sources	3.51	Rise of distrust and pressure for increased transparency	2.85	Pressure for companies to increase efficiency and productivity	2.75
23	Rise of IoT, sensors and smart infrastructure	3.51	Global divide and increased social inequality	2.81	Private participation in infrastructure	2.78
24	Ageing infrastructure	3.53	Sharing economy	2.75	Rise of green energy sources	2.83
25	Urbanisation and population growth	3.65	Multipolar world	2.67	Globalisation and international trade	2.84

Society and workforce | Technology | Geopolitics and regulation | Market and customers | Sustainability and resilience

Appendix 2:

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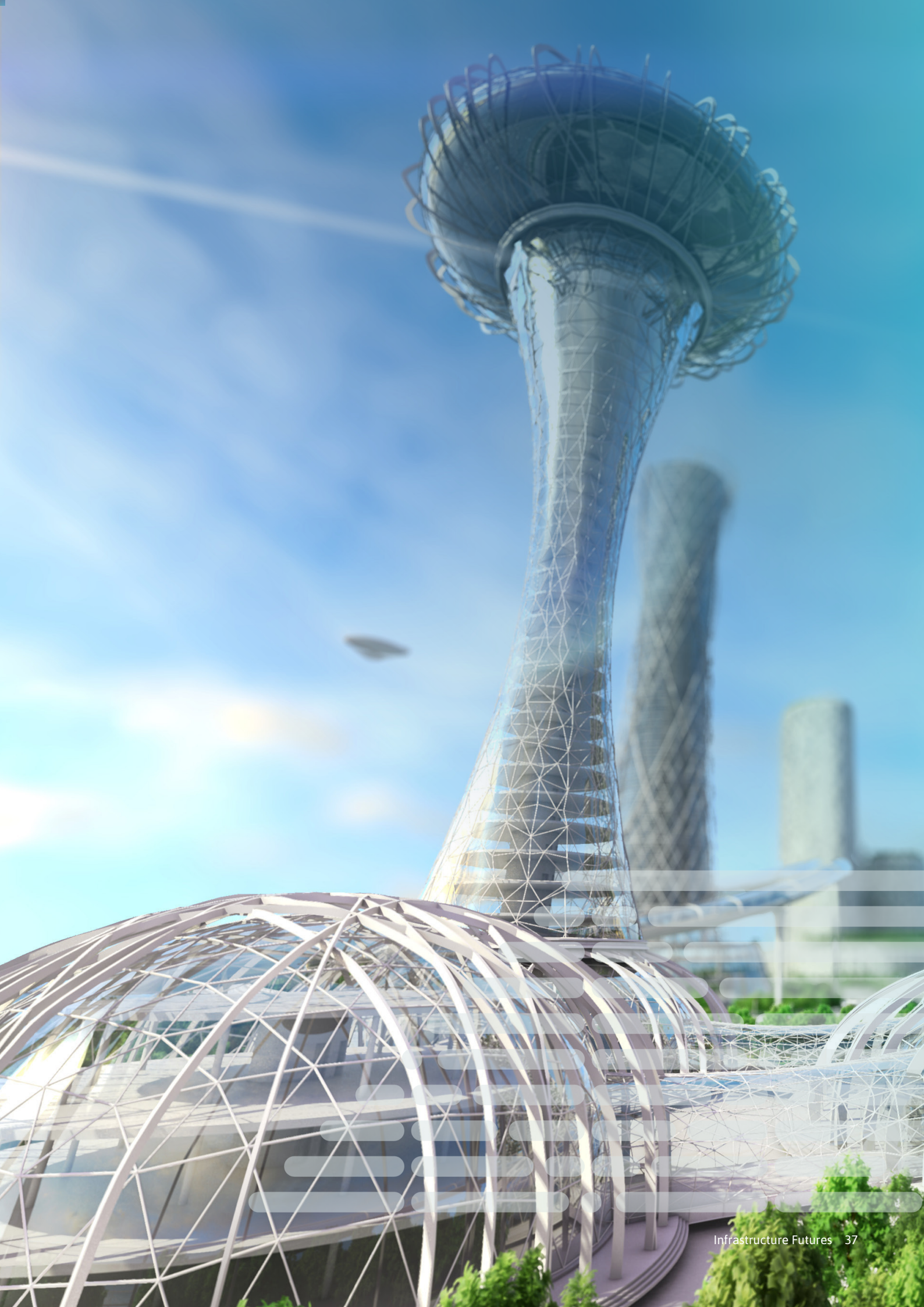

CONTACT US
GLOBAL INFRASTRUCTURE HUB

P: +61 2 8315 5300

E: contact@gihub.org

W: gihub.org

@gi_hub

global-infrastructure-hub

@globalinfrastructurehub

ACN 602 505 064

ABN 46 602 505 064