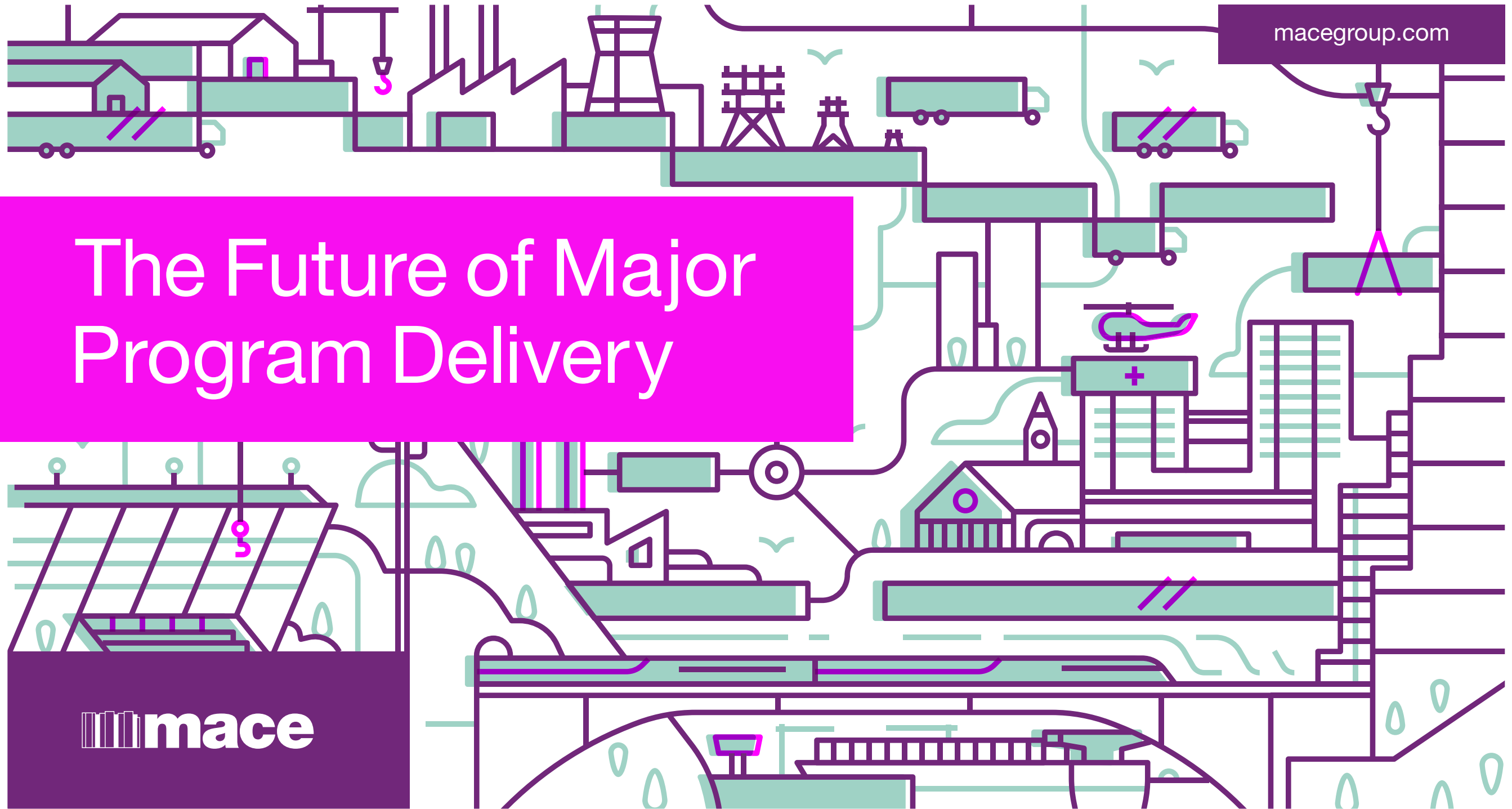


The Future of Major Program Delivery

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Mace. Delivery consultants and construction experts

The Future of Major Program Delivery

In this report, currencies are given
as US dollars unless stated otherwise.

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Foreword: Davendra Dabasia, Chief Executive Officer, Mace Consult

For more than 20 years, I have been involved in the delivery of some of the most iconic programs and projects in the world. A standout moment for me was playing my part in the exceptional team that delivered venues for the London 2012 Olympic and Paralympic Games. Not only did the Games attract millions of visitors worldwide and generate significant value and pride for the UK, the construction of the venues, infrastructure and the entire Park was considered to be an exemplar for how to deliver complex, large-scale capital developments effectively. The program also taught us a lot at Mace, helping to guide the evolution of our global consultancy business. The experience was invaluable and helped shape what we stand for. This influences the work we do and how we deliver for clients across the world.

The London 2012 Olympic and Paralympic Games was one of the first times that a ‘delivery partner’ model – a truly collaborative delivery approach – had been used in a meaningful way. It enabled the entire program to be delivered early and below budget, with venues and infrastructure assets completed a year before the Games began and with an underspend of £600m (\$800m). It also attracted ongoing investment, generating a legacy of socioeconomic value that lives on to this day.

However, more than 15 years later, instead of applying and building on that model’s proven performance, and following the general consensus that collaborative models lead to better outcomes, our industry continues to face significant challenges managing and delivering on promises.

Analysis shows that more than 90% of megaprojects (those valued over \$1 billion) experience cost and schedule overruns. The root causes remain the same: unclear governance structures and funding agreements; overly optimistic estimates; poorly defined scope; disjointed execution; and conflicts often exacerbated by poorly defined program objectives and failure to integrate project organizations, supply chains, operating systems and technologies.

Nevertheless, we are at a turning point – a time of record investment, with more than 11,000 live mega programs and projects and 250 giga programs and projects (those valued at more than \$10 billion) around the world. This is an estimated 280% increase compared to 15 years ago and represents more than \$15 trillion of expenditure, with significant consequences for countries, climate and people.

Our insights, from a dataset of more than 5,000 mega and giga programs and projects around the globe, and interviews with 30 industry leaders, provide an indication of the state of

major program and project delivery today. We are exploring common challenges, lessons learned and, most importantly, practical steps that leaders can take to promote effective delivery of current and planned projects.

A core part of the solution is a concerted industry shift towards truly collaborative delivery approaches, whether that’s alliancing, progressive design and build or the delivery partner model. Irrespective of the specific approach, what’s important is the formation of a truly integrated delivery team, consisting of clients, consultants, contractors and supply chain organizations, that is empowered to take best-for-program decisions across the entire lifecycle and focused on achieving long-term beneficial outcomes.

Time and again, I’ve seen the power of collaboration in practice. What’s more, there are studies suggesting that more collaborative approaches significantly improve delivery outcomes. Evidence has shown a 4-13%^{i,ii} reduction in costs compared with less

collaborative contracting models and a 50% reduction in the risk of the project being delivered late^{iii,iv}.

A collaborative mentality only works if the wider ecosystem allows for it. What that means in practice is genuine alignment on meeting shared goals, with everyone pulling in the same direction to achieve them on behalf of the client. Shared success should mean shared reward too. An ecosystem that operates fairly will boost engagement, morale and commitment.

It is within this context where I believe we’re leading the charge at Mace. Blending our unique focus on program and project management with the global insights of our delivery consultants and the practical knowledge of our construction experts, our collaborative approach is unique in that we understand how to deliver. We act as a trusted partner across the entire program lifecycle, not simply providing strategies for delivery, but executing them. At the program level, this means we actively shape and optimize the approach. At the enterprise

level, we help to develop a one-team culture, focused on unifying all parties against common goals.

I hope this report serves as a practical, honest, and ambitious road map to change the way we deliver large-scale programs for the better.



— Davendra Dabasia, Chief Executive Officer, Consult, Mace

Foreword: Priya Jain, President, Mace Americas

With more than three decades in capital delivery – many of them alongside Mace – and now as President of Mace Americas, I've had the privilege of working with extraordinary clients and colleagues to deliver complex, transformative programs across sectors and geographies. From private-sector industrial developments to publicly funded megaprojects, these experiences have offered a clear vantage point on what drives success. And what holds us back.

One of my most formative experiences was supporting the London 2012 Olympic and Paralympic Games as part of the team advising the Olympic Delivery Authority. More than a decade since, it remains a benchmark in major program delivery – not only for being completed ahead of schedule and under budget, but also for the long-term legacy it

continues to create through economic renewal, community investment, and urban regeneration.

Lessons I learned earlier in my career working with capital-intensive industries still resonate – particularly in the energy and process sectors – where large, complex programs were routinely delivered at speed and scale. While the tools and technologies enabling effective execution have continually advanced, the real breakthroughs happen at the intersection of human and digital intelligence. And when I reflect on what consistently underpins successful delivery, two golden threads stand out: economies of scale and a culture that enables collaborative execution.

Economies of scale

Programs of significant size and ambition must generate returns that far exceed capital

outlay. These returns can be financial, like cost efficiencies, productivity gains, and long-term revenue, as well as societal, such as job creation, business growth, enhanced tax revenues, and community development. Realizing that value requires acute management discipline in how projects of scale are planned, funded, and delivered.

In the public sector, regulatory complexity, fragmented jurisdictions, and funding constraints heighten the challenge. In the private sector, while access to capital is more fluid, via market capitalization, liquidity, or borrowing capacity, the urgency to deliver returns is much higher. Investors expect to see capital programs generate value in shorter timeframes, which accelerates development cycles and raises the stakes on delivery efficiency.

As costs escalate, private-sector clients increasingly turn to strategic partners focused on delivery – not just to manage scope and risk, but also to enhance performance, integrate systems, and drive productivity at every stage. Public-private partnerships (P3s) that

have been key to enabling infrastructure development in emerging economies are now becoming essential in mature markets as well, as inflation, resource constraints, and aging assets heighten demands for capital and delivery expertise in tandem. Complexity also drives owners to pursue P3s to achieve requisite economies of scale and long-term benefits.

A culture that enables collaborative execution

Collaboration has become another industry imperative. While collaborative models fostering integration like alliancing, progressive design-build, and delivery partnership demonstrate clear benefits, many attempts fail to realize their full potential in practice, likely because collaboration is misunderstood. It's not a process, nor is it about consensus; it's a culture. And culture, more than any contracting method, strategy or operating plan, determines whether a program succeeds or stalls.

This demands a skill set beyond traditional engineering and construction. It requires fluency in behavioral and sociopolitical

dynamics, as well as cross-functional leadership. It's not enough to align scopes, schedules and frameworks or set common values, expectations, and incentives with project teams.

Since culture is an amalgamation of experiences, assumptions, and motivations of everyone involved, it's rarely written but always influential. If ignored, it can be a subversive constraint – like a submerged iceberg with the power to wreck even the most technically sound plans. Yet, if attentively considered and developed with intention, culture can be a performance multiplier enabling greater transparency, agility, and accountability.

High-performing collaboration starts with first getting clear understanding of human factors at play by surfacing individual and institutional drivers, then cultivating shared appreciation and experiences. That sets the stage for effective governance that facilitates – not impedes – decision-making, and an integrated management framework that unifies people, organizations, systems, and technologies to align execution

with strategic aims over the life of the program.

To deliver at pace and to scale requires constantly striking the right balance of technical, organizational, and cultural leadership from the front line to the management ranks. It's an industry mindset shift from fragmented execution to fully integrated, carefully orchestrated delivery, and it won't happen by accident. It's a conscious choice to lead and work together in concert, not just beside each other.

As future programs grow to historic proportions – so do opportunities to improve outcomes, by applying collective capabilities in true collaboration to achieve more than any of us might alone.



— Priya Jain, President,
Mace Americas

Executive summary

Major programs have entered an era of unprecedented investment, unmatched scale and uncommon complexity. Today, there are over 11,000 mega and 250 giga-projects and programs in delivery across the world. Just this group of programs – categorized as having a value of more than \$1 billion and \$10 billion respectively – represent more than \$15 trillion in capital investment. However, despite this momentum, the industry continues to grapple with persistent challenges to delivery, with associated cost overruns, schedule delays, and under-realized benefits remaining the norm rather than the exception. Failure to get on top of these challenges puts at risk more than \$1.5 trillion of economic growth by 2030.

This report, grounded in an analysis of more than 5,000 mega and giga-programs and projects, and enhanced by insights from over 30 industry leaders, offers a frank assessment of the barriers to

effective delivery. It identifies the systemic issues that continue to undermine performance, ranging from optimism bias and fragmented governance to talent shortages and misaligned incentives. These challenges are not confined to any one geography or sector; they are global, structural, and deeply embedded in the way projects are conceived, procured, monitored and managed.

Even so, there is a promising opportunity for change. This report calls for a fundamental shift towards collaborative delivery models, pointing to ten core pillars as a guiding framework for anyone in the industry. These are approaches that prioritize robust governance, integration, common goals, shared accountability, and long-term value over transactional relationships and short-term gains. Drawing on lessons from the London 2012 Olympic and Paralympic program, Metrolinx in Toronto, the Hudson Tunnel Project in the US, and Peru's

resilience-driven National Infrastructure Reconstruction, this report illustrates how collaborative frameworks can significantly improve intended outcomes.

Along with collaboration, the industry must evolve through innovation, with the transformative potential of digitization and AI at the vanguard to revolutionize

delivery. From predictive analytics and digital twins to intelligent procurement and real-time risk monitoring, technology is not a panacea for problematic programs. Rather, it's a powerful enabler of better planning, more informed decision-making and improved productivity.

This report serves as both a diagnosis and a roadmap,

challenging industry leaders and influencers to reflect on the barriers they face (and perhaps, in some cases, enable), while offering twelve recommendations for actionable solutions supported by research.

From taking steps clearly defining baseline scopes with realistic cost envelopes, to purposeful procurement

seeking supply chain partners who 'fit' the culture, to ensuring knowledge sharing and lasting legacy benefits: the opportunities to improve are here for the taking. When clients, consultants, suppliers, and contractors align by prioritizing the best interests and outcomes envisioned, we can unlock the full promise and value of every project.



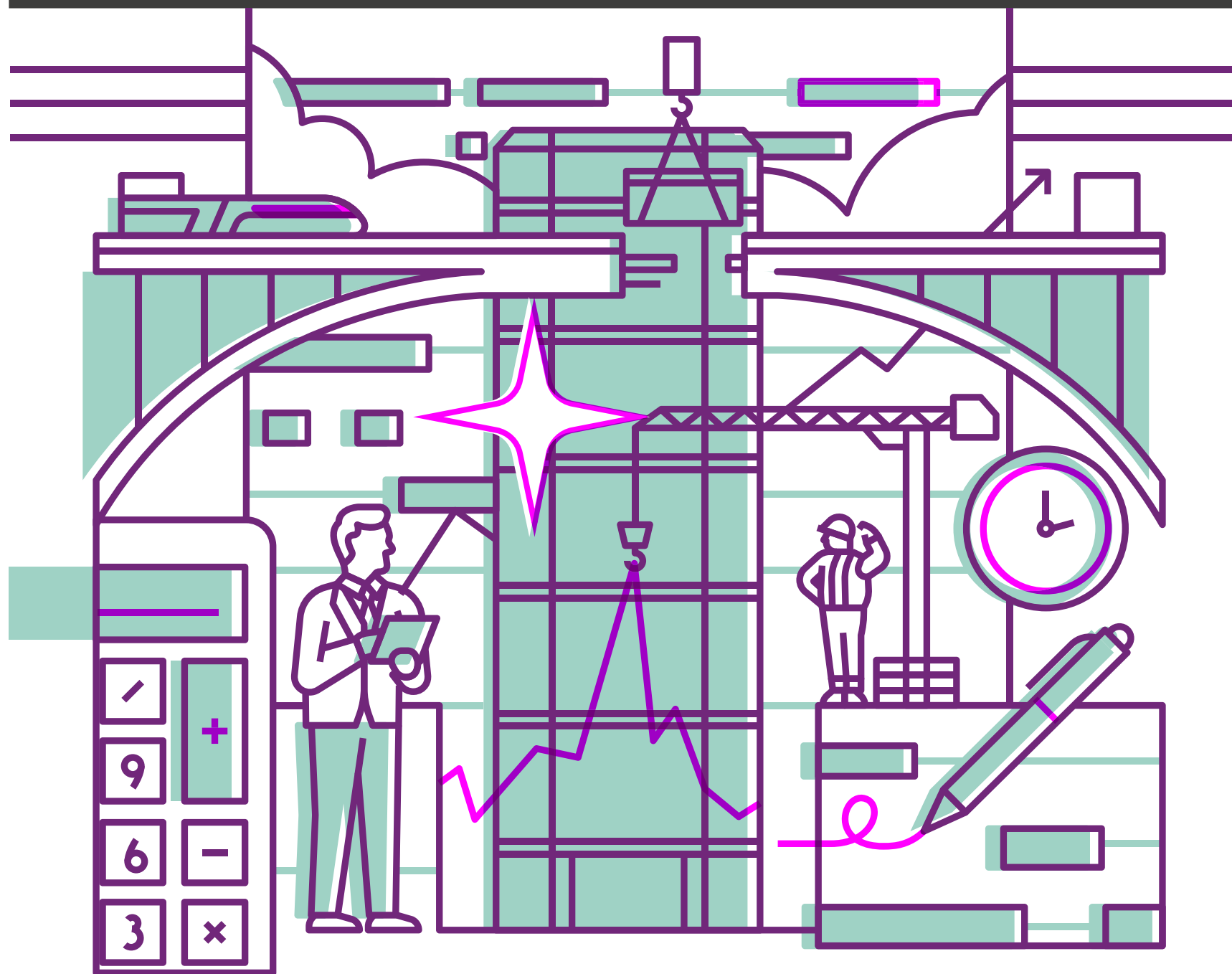
Since I established Mace's major programs offering in 2013, the urban environment has changed beyond recognition; shaped by innovative processes, intelligent people and iconic projects. Mace has played a prominent role in driving the major programs boom, bringing lessons from around the globe, and across both our consultancy and construction teams, to help foster the collaboration that is so crucial to delivering modern, fit-for-purpose and resilient buildings and infrastructure.

— Jason Millett, Group Chief
Executive Officer, Mace



Setting the scene

1



Setting the scene



Across the world, projects and programs are becoming larger, more complex and more expensive. We are no longer in an era of mega-scale programs (valued at more than \$1 billion). Today, we are in an era of giga-scale programs.

'Giga' scale applies to capital programs that exceed \$10 billion in investment, usually spanning a decade or more, with significant potential to transform regions and even nations. If they are not well delivered, they can substantially erode value by diminishing productivity, service capacity and resources needed to meet current and future demands.

The findings and recommendations we present in this report have relevance for both projects and programs of scale at a time of record public and private investments in infrastructure, advanced manufacturing and technology facilities, systems and assets around the world.

Our research shows that the number of live megaprojects and programs has ballooned by 280% over the past 15 years to more than 11,000, with over 250 programs of giga-scale currently in development or on the path to delivery. Altogether, these programs total more than \$15 trillion in capital investment. In review of documented reports, our research points to particularly strong construction activity in India, the USA and

China. India's development, in particular, is seeing a significant surge. In 2024, the total value of India's construction market was \$1.04 trillion, and is expected to grow to \$1.21 trillion by the end of 2025. By 2030, the nation's construction industry is slated to balloon to \$2.13trillion^v.

Behind the US, China and India, the UK, Saudi Arabia, and the United Arab Emirates (UAE) also show healthy growth in their construction pipelines.

We also note growth driven by significant urbanization, especially in North America and Latin America^{vi}, with world-leading urban population rates of 83% and 82% respectively.

When exclusively counting capital investments of mega- and giga-scale worldwide, the US, India and Saudi Arabia lead all other nations^{vii}.

Yet, despite the rise in construction and very large projects specifically, the ability to deliver on-time and budget with intended socioeconomic value has continued to fall short, and in some cases, has regressed. While we find that this is being countered to some degree with best-practice collaborative

delivery models, we also see more barriers to success than ever before.

The issue goes beyond the question of delivery approach, as geopolitical, socioeconomic, regulatory, climate and environmental circumstances affect development outcomes in a variety of ways. Nonetheless, truly collaborative, multi-disciplinary effort often proves to be the only solution to resolve persistent problems.

Large-scale programs especially present tangible opportunities for workforce and supply chain development, including key measures of

safety, quality, productivity and prosperity. Yet our analysis shows that across the sample of 5,000+ megaprojects we reviewed globally, 11% stand at risk of significant delay or cancellation, at a hefty price.

In view of previous research and the subsequent book by Professor Bent Flyvbjerg entitled, '*How big things get done*', nine out of ten megaprojects experience cost overruns. While these averages remain constant for the industry overall, it's not uncommon for mega- and giga-scale projects to exceed their budgets by 50% or more.

Since 2010, our research shows that the number of live megaprojects and programs has ballooned by...

280%

These instances are not merely historical hangovers. Such challenges continue to escalate, with urbanization, technological advances, and the need to close infra-structure gaps and bolster climate resilience driving greater demand and urgency for large-scale capital developments. This holds true in both mature and emerging economies, for public infrastructure and private industries. As programs grow larger, more complex and expensive, socioeconomic stakes take on greater weight, with significant potential to generate value or diminish it in real terms.

Applying lessons from past megaprojects, we know that bias for action and over-optimism often influence misguided decisions. Nobody sinks billions into capital investments without expecting to generate a positive return for investors and society, but the ability to achieve intended outcomes hinges on causality. This requires activation of well-defined, multidisciplinary management levers proven to drive effective execution and results by design.

Anyone who thinks this is solely an issue for a small handful of countries would be mistaken. Yes, some countries have better delivery rates than others, but even in the highest performing nations, a sizable proportion of large projects and programs are delivered late and over budget.

A recent research project by Middlesex University Dubai^{viii}, looking across 95 organizations in the Middle East and North Africa, found that 82% of respondents expect their projects to face disputes within the next three years. The main issues cited are delays (90%), alongside claims and disruptions such as limited availability of materials and equipment, supply chain and service coordination issues, utilities (86%), changes in scope (86%) and additional, unforeseen costs (86%).

In addition to these delivery challenges, many programs face significant talent shortages, especially for people with relevant experience, and find it difficult to build capable teams to manage the delivery of large, complex projects and programs over the long timeframes they typically require.

Balanced against the value of major programs brought to fruition are the costs and consequences of *not* doing them.

For example, the reason the \$16 billion Hudson Tunnel Project is considered America's most urgent infrastructure priority is because it will resolve chronic service disruptions at the busiest point of the US Northeast Corridor, the rail transit route that runs from Washington, DC to Boston — a megalopolis that is home to \$2.6 trillion of the nation's annual economic output and is the world's largest regional economy. The real economic cost of this single point of infrastructure failure far exceeds the project cost to resolve it — amounting to \$16 billion *every year* in productivity losses, \$22 billion lost in property value, and \$7 billion in tax revenue losses.

Acknowledging the stakes, the NY-NJ Gateway Development Commission opted for a collaborative model (with a Mace-Parsons-Arcadis joint venture serving as delivery partner) to make the most of the investment. Already, the project is supporting 20,200 jobs and \$4.5 billion in economic output,



and over the life of construction, it will create 95,000 jobs and generate \$19.6 billion in economic activity.

In terms of the employment, the average Fortune 500 company (the world's 500 largest companies by revenue) employs 140,000 people, while the New York Metropolitan Transportation Authority's 2020-2024 capital program^{ix} alone accounted for 170,800 full-time jobs.

Given the sheer value associated with mega programs, the aim of this report is to consider why they continue to encounter delivery problems, despite years of studies documenting critical success factors and measures proven to drive effective delivery.

Why have we not seen marked improvements? And why, in some instances, does it seem that delivery has regressed?

In an era of accelerating digital modeling, automation and augmented intelligence being applied in the industry, we'd expect to realize the potential that AI and digitization offer to streamline delivery and address common challenges, risks, and pitfalls.

Our research provides insights drawn from analysis of a global data set of more than 5,000 mega and giga-projects, a review of global academic research, and in-depth interviews with more than 30 of the world's foremost major program leaders.

While there is no singular 'silver bullet' solution to the delivery conundrum, the insights drawn from research for this report provide fact-based guidance for organizations involved in complex, large-scale capital programs. To do so, this body of work serves as a considered and consolidated program management and delivery framework to inform their understanding of issues they are likely to encounter, their root causes, and actionable recommendations to progress effective delivery, by measures that realize the full promise and value potential inherent in these large-scale programs.

Global delivery in numbers

2



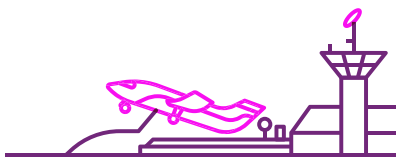
Global delivery in numbers

Before we dive into why mega and giga-projects face challenges, the solutions and what the future of major project delivery looks like, it is helpful to orient ourselves with an assessment of the delivery landscape of today and recent years around the world.

To do so, we have undertaken a new analysis of a global dataset of more than 5,000 megaprojects (valued at \$1 billion or more) and giga-projects (valued at \$10 billion or more). To build the database we sourced information from GlobalData, used AI tools and conducted our own academic desk research from a selection of geographies that reflective of the

global industry, including delivery track records in both mature and evolving economies, and those evidencing notably active capital pipelines. The locations we focused on for the purpose of verifiable research include the US, Canada, Peru, Colombia, Saudi Arabia, UAE, Philippines, Hong Kong, India, Australia, UK and Ireland, with reliable data going back to 2010.

This data set allowed us to better understand important delivery trends across varied types of mega and giga-projects, common delivery and cost issues, and factors placing projects at risk of missing delivery targets. The technical appendix included at the end of this report provides further information and caveats about this data set for transparency.



The projects within the data are grouped into six types:

1 Commercial and leisure
Including buildings and facilities associated with retail, hospitality, entertainment, and transport-related functions, such as resorts and hotels, restaurants, cinemas, stadium complexes, offices, retail stores and mixed-use centers.

2 Energy and utilities
Comprising facilities and infrastructure used to produce, process, distribute and manage energy, power and water services.

3 Industrial
Referring to facilities dedicated to production, distribution and materials management, including manufacturing plants for automotive, aerospace, electronics, food, textiles, pharmaceuticals, and specialized facilities for batteries, fuel cells and semiconductor fabrication, as well as data centers.

4 Infrastructure
Focusing on transportation, communication, and essential services and systems including rail transit, roads and highways, airports, ports and marine facilities, fiber optics and underwater transmission lines.

5 Institutional
Encompassing facilities for public, civic, non-secular, defense and social service purposes, including schools, universities, healthcare facilities, and a broad range of civic and government institutions such as libraries, police and fire stations, courthouses and correctional facilities.

6 Residential
Including all types of single- and multi-family housing developments, ranging from planned communities to entire districts and new towns.

The top lines

Unsurprisingly, the United States tops other nations in the sheer number of mega- and giga-projects and programs, with 1,663 announced, active and completed since 2010, followed by India with 729, Saudi Arabia with 577, and the UK with 484.

For giga-projects specifically, the USA again leads the pack with 88, followed by India with 43, and Saudi Arabia, also with 43.

The sectors leading in the number of megaprojects in the data set are...

1 Energy and utilities
1,389 megaprojects

2 Residential
1,012 megaprojects

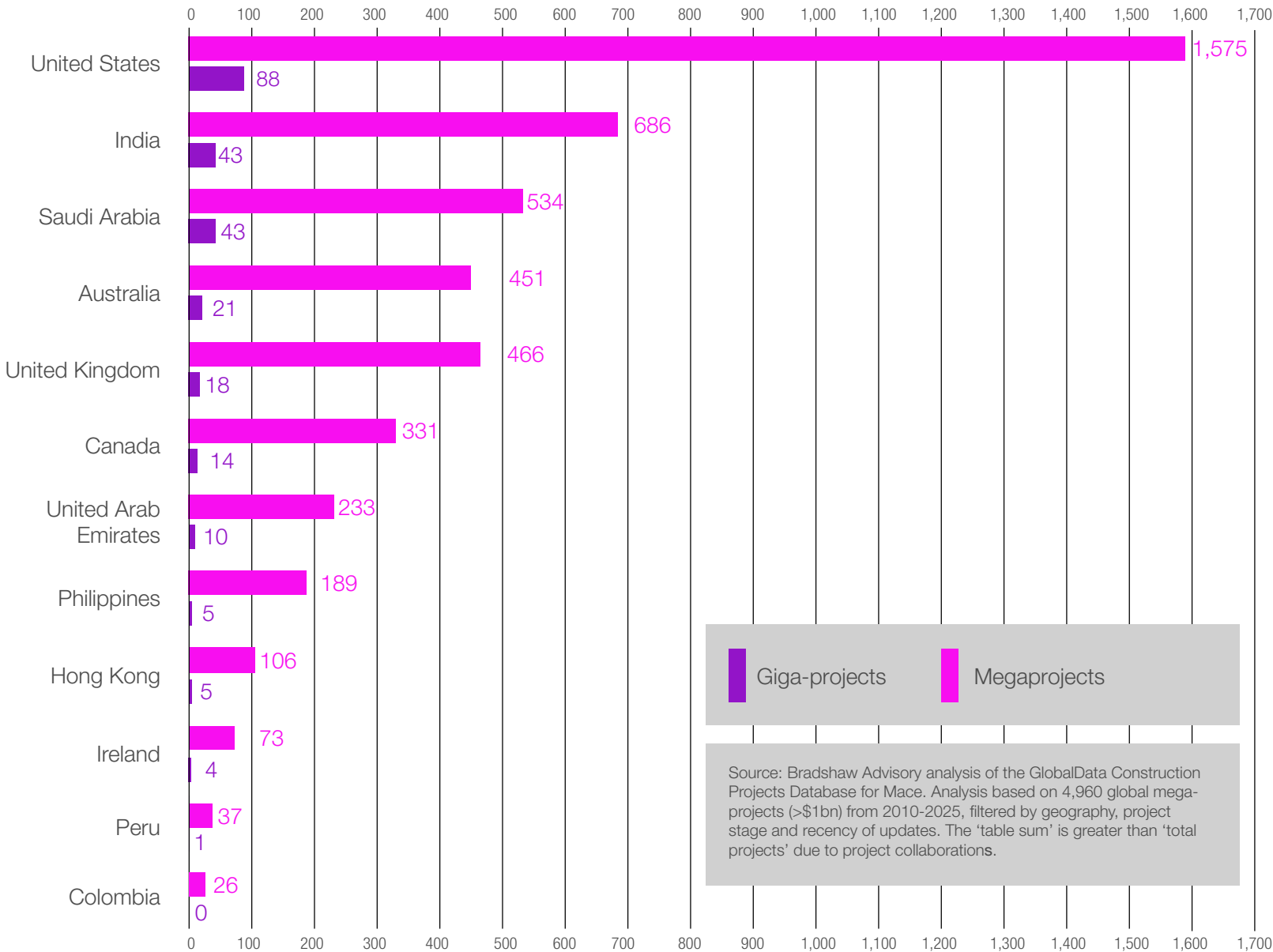
3 Infrastructure
858 megaprojects

These allocations likely reflect a mix of regional and global trends, including the rise of the fourth industrial revolution and energy-intensive requirements such as for data centers, as well as efforts improve energy independence and reduce emissions, while serving a growing world population set to hit around 10.3 billion people by the mid-2080s*.

The mega development boom especially reflects ballooning urbanization rates led by the Americas, where 83% of North America's population and 82% of the population in Latin America live in urban areas.

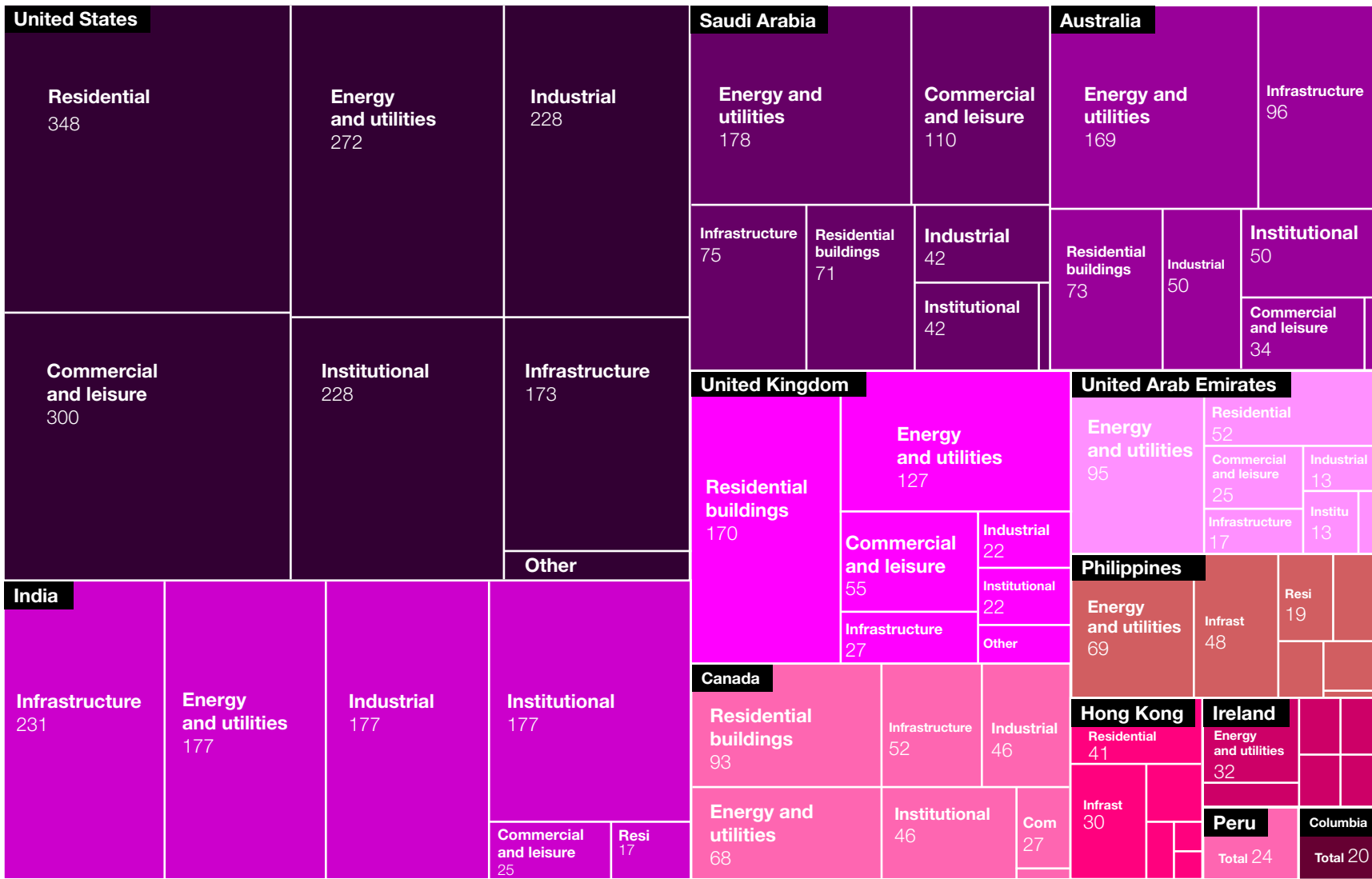
This trend is expected to continue, as the UN predicts that by 2050, 70% of the world's population will live in cities compared to 58% today, driven by access to educational, economic and social opportunities. And, in both mature and developing economies, the acceleration of modern living, digital connectivity and climate resilience trends place even greater demands on infrastructure, housing and community development.

Megaprojects and giga-projects worldwide



The distribution of megaprojects worldwide

\$1bn+ projects announced since 2010, active or complete, select countries



Source: Bradshaw Advisory analysis of the GlobalData Construction Projects Database for Mace. Analysis based on 4,318 global megaprojects (>\$1bn) from 2010-2025, filtered by geography, project stage and recency of updates.

The active megaproject pipeline

The number of active mega- and giga-projects and programs around the world has increased nearly fourfold since 2010.

Within our geographic reference class, Saudi Arabia has seen one of the highest rates of increase in the world, with 64 megaprojects in 2010 and 476 in 2025, a 643% increase. This is driven by the country's ongoing transformation under the Vision 2030 plan, which includes the likes of NEOM, The Red Sea Project, Diriyah, Qiddiya, King Salman International Airport and New Murabba developments.

The USA, UK and India also show significant growth in megaprojects. In 15 years, the USA's pipeline grew from 275 active megaprojects of over \$1 billion in value to 1,334 in 2025, a 385% increase. Over the same period, the UK saw a 200% increase and India's pipeline grew by 153%.

Kingdom of Saudia Arabia Active megaprojects

↑ 643%

United States of America Active megaprojects

↑ 385%

United Kingdom Active megaprojects

↑ 200%

India Active megaprojects

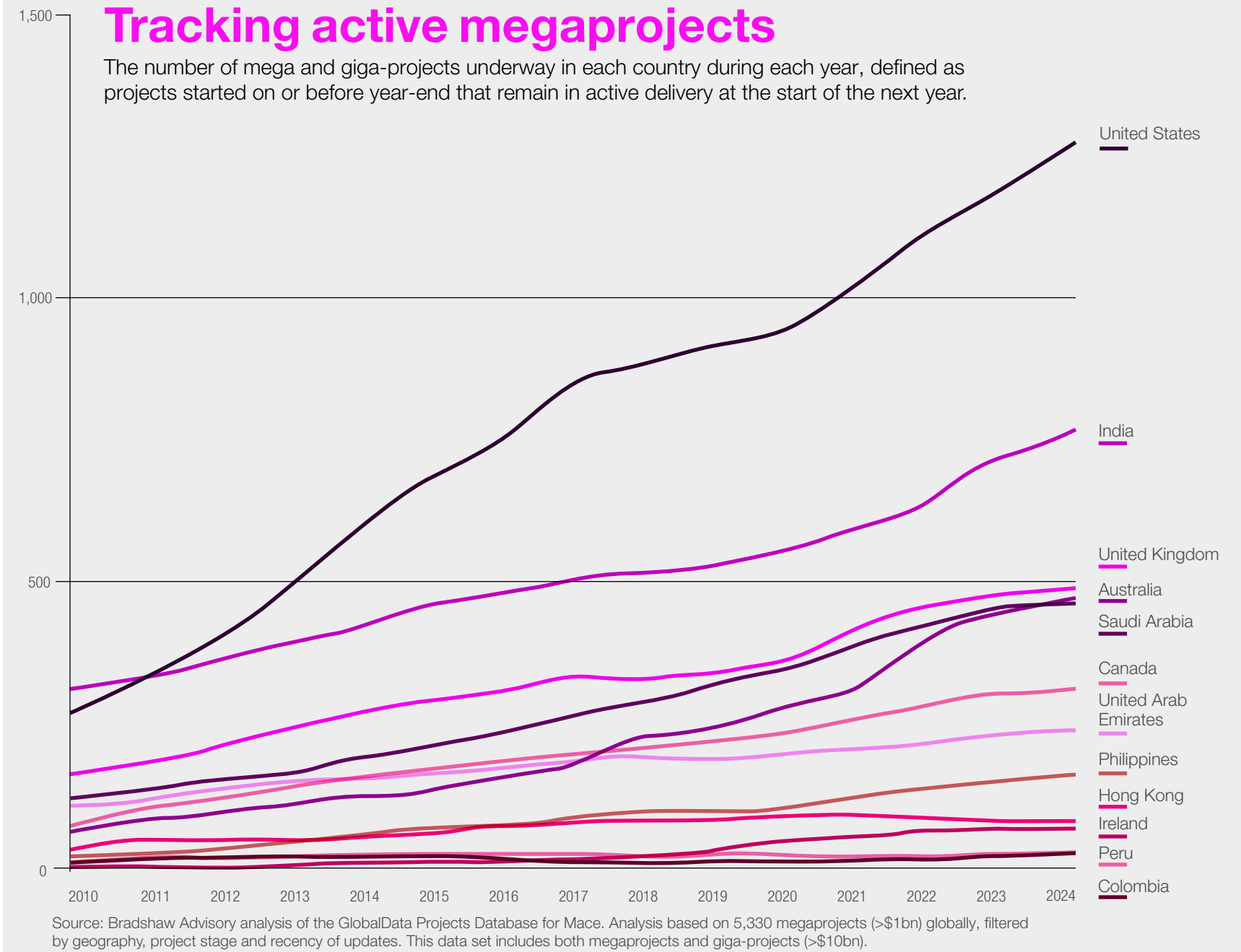
↑ 153%

The increase in large-scale infrastructure spending reflects wide recognition that such investments serve as a catalyst for near- and long-term economic growth, sparking economic multipliers beyond their capital spend. A meta-analysis by the G20 Global Infrastructure Hub^{xi} found that public investments in infrastructure return an average multiple of about 0.8 times within one year and 1.5 times in 2 to 5 years. So, in the first year, \$1 invested adds an average of \$0.80, and in 2 to 5 years, returns an average of \$1.50 in economic output for ever dollar invested. Alongside macroeconomics, the type of infrastructure also influences return multiples. For example, the American Public Transit Association notes that transit infrastructure investments yield higher returns because they stimulate adjacent residential and commercial development, multiplying every dollar invested by an average of 4 to 5 times^{xii}.

While this report focuses on mega- and giga-scale projects, it is useful and interesting to reflect on this data in the context of recent global construction trends. Data

reported for construction workloads from the RICS Q1 2025 Global Construction Monitor^{xiii} reflect the top three growth rates across the period were in the UAE, Saudi Arabia and India. Strong growth in construction activity, particularly in the Middle East, is echoed by a high score in the corresponding Construction Sentiment Index. Combined, the datasets point to confidence in, and commitment to, construction activity across the region and follow on from a similarly positive Q4 2024 outlook. In the US, while overall sentiment remains strong, the pace of growth has slowed, according to Q1 2025 RICS data, while that for Europe presents a mixed picture, with Spain indicating particularly strong headline growth and Ireland also trending positively. The UK, meanwhile, showed a flat headline in Q1 2025.

While the RICS data is a point-in-time snapshot, the reasons behind the variance in these figures support our view that the challenges and obstacles to effective program delivery are multifaceted and subject to external influences often beyond the control of project owners and managers.



Lifecycle spans

The longer a project goes on, the greater the chance that a significant external event will transpire with the potential to knock it off course (a health pandemic, material-cost or price shocks, policy shifts, or geopolitical clashes).

Across our database, Ireland has the shortest average duration (from announcement to completion) for mega-projects, averaging 5.8 years (although the absolute number of projects is much smaller). In contrast, megaprojects in Peru have the longest average in our dataset, over 13 years, closely followed by the UK at nearly 12.5 years and India at around 11.6 years. While scale and complexity are primary culprits, we learned in our interviews that longer spans also relate to high levels of bureaucracy, challenges gaining approvals, stop-start funding cycles, and external factors like El Niño floods in Peru.

That said, Saudi Arabia and the US average similar durations of just under 9 years, even with programs of the largest scale globally. Other locations like the UAE, Hong Kong and Canada fall in the 10- to 11-year range.

Average delivery times also vary significantly by project type and country. This comes down to a variety of factors, including site constraints, environmental factors and pre-existing conditions; the number and complexity of technical, jurisdictional and stakeholder interfaces; interdependencies with utilities, supplies, and supporting infrastructure; regulatory requirements; and the unique aspects of the build, among other variables.

Infrastructure programs, in particular, show a dramatic spread in the pace of delivery within each respective country (although Australia is remarkably consistent, perhaps due to the widespread use of collaborative delivery approaches like alliancing^{xiv}). In the UK, the mean project duration is much higher than in other countries: the 75th percentile of project spans in the UK runs 50% longer than the next closest geography, Hong Kong.

When examining why this discrepancy exists, the explanations we heard in our interviews tracked with findings documented in the 2024 National Infrastructure Commission (NIC) report

citing wider underlying factors at play. In its paper, titled ‘Cost drivers of major infrastructure projects in the UK’, obstacles hampering timely delivery included a lack of clear vision and strategic direction; insufficient informing by government authorities on the project pipeline; and failing to build confidence in supply chain capacity required to deliver projects of scale. Bureaucracy also was cited as a problematic issue, given that the average time taken to secure approvals doubled between 2009 and 2019. Along with the obvious impact on project timelines, such delays come at a cost.

While the paper flags additional challenges driven by project clients and sponsors and acknowledges supply chain constraints, the overarching concern points to lacking strategic direction centrally as an impediment to delivering at pace in the UK.



Democracy is expensive and takes time, and it's not gotten any easier. If anything, it's become more difficult.

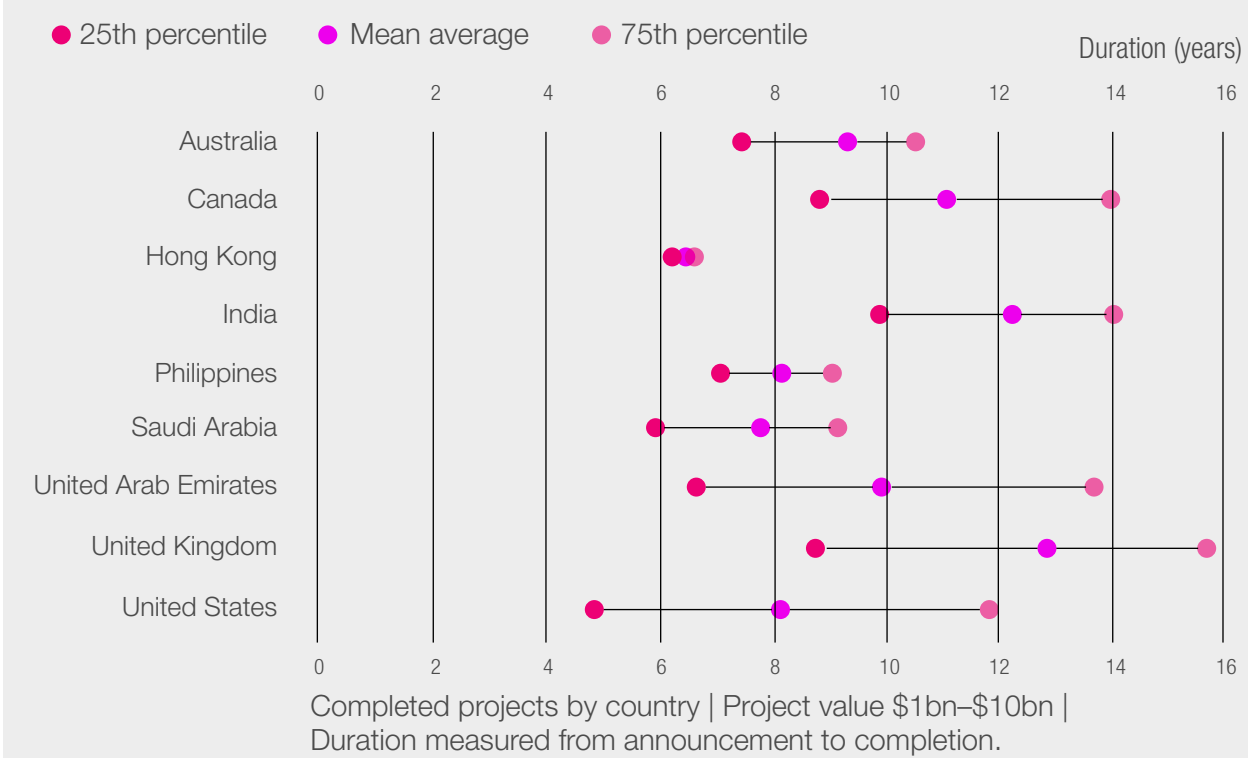


— Sir John Armitt,
Former Chair, UK National
Infrastructure Commission

“Within the UK, we see a parochial approach to planning and consenting which creates substantial inefficiency. For example, we are often required to do additional (non-value-added) work to demonstrate compliance with a specific requirement of the planning process, when our thinking and understanding of what is required is already more advanced. We can therefore find ourselves producing a report which simply unlocks the next more detailed report; this wasted effort and inefficiency adds little value, increases costs and delays programs. That’s a fundamental process and system failure.”

— Phil Brown, Managing Director,
Major Nuclear Capital Programs,
Babcock International Group

Energy and utility megaproject duration



The varied picture of mega-project duration graphed by sector and country shows differences beyond delivery efficiency. While scope and scale certainly play their part, so do a host of other factors, like policy and regulatory requirements of the respective industries and countries. The differences also point to opportunities to learn from and apply lessons of those reflecting shorter time frames.

For energy and utility mega-projects, the US, Saudi Arabia Philippines and Hong Kong show more efficient progression from announcement to completion. Longer timelines in India, in part, reflect challenges unique to aging energy infrastructure requiring upgrades and integration of renewables into a portfolio that's still in the early stages of energy transition.

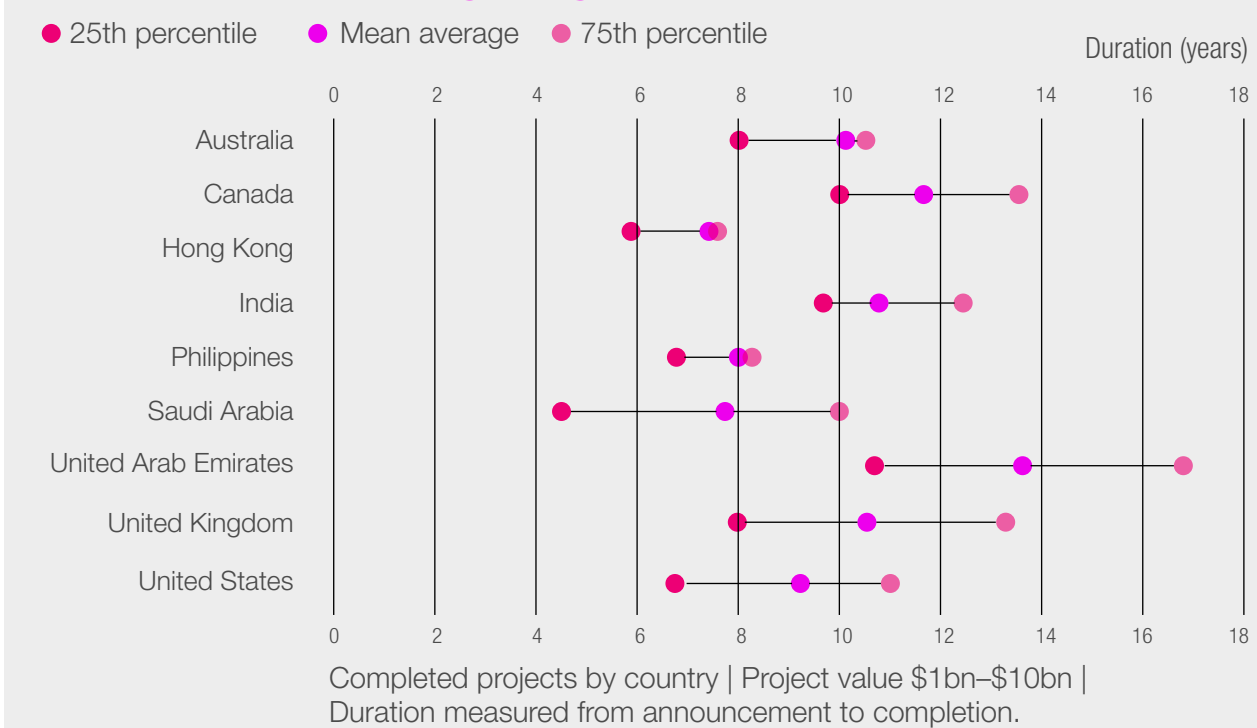
The opportunity and ambition for India to progress much needed energy infrastructure enhancements is underscored by the sheer number of megaprojects under way requiring reliable supply. The UK shows the longest timelines but, as noted above, evidence points to legislation, regulation and consents as common causes of delay. This is true for both energy and

utility programs. Like in India, connecting large generation resources to the UK grid may add more time to project schedules, even if other elements are in place. For residential megaprojects, there is a significant spread in delivery performance with some of the quickest megaprojects delivered in just over four years

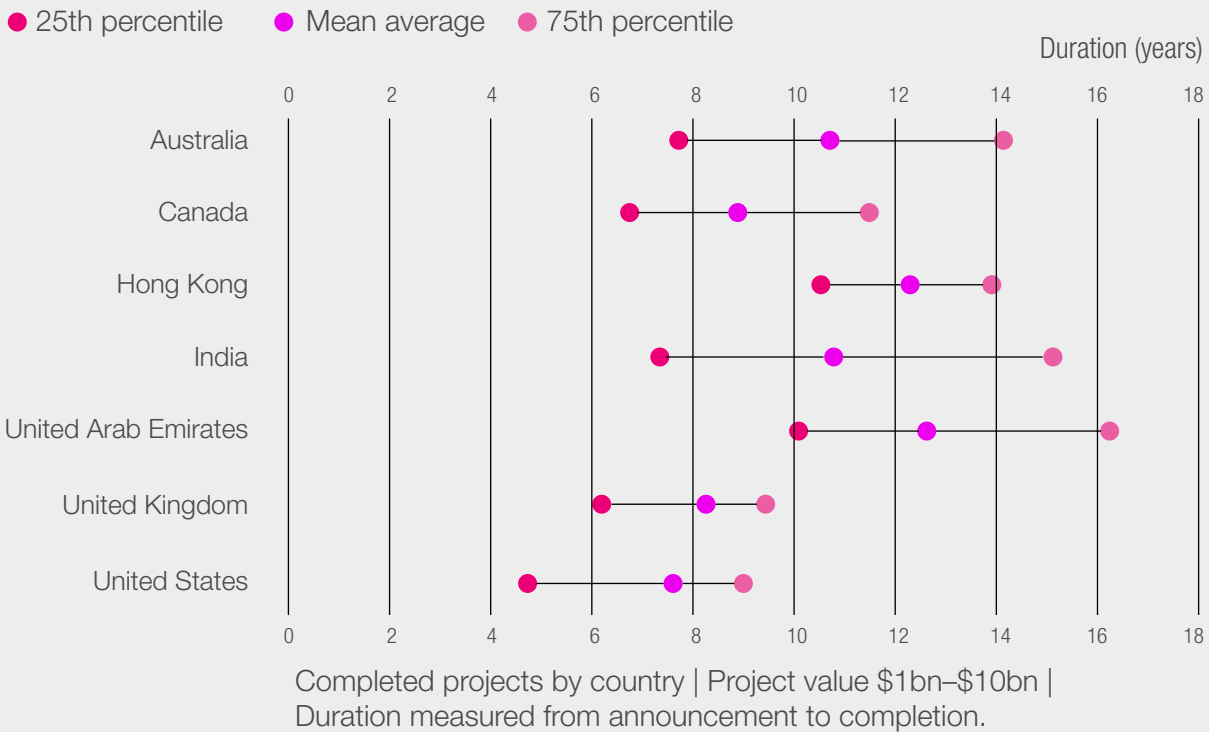
and the slowest taking 17. Hong Kong is again a strong performer, with not only low average completion times, but also a tight spread within the data suggesting a consistency of approach and management. The UAE, famed for its iconic and towering skyscrapers, shows longer than typical durations in the residential

sector. We attribute this to the sheer scale and complexity of height-defying projects, which naturally require more time across the development lifecycle, from planning through construction, rather than any shortcomings in delivery capability.

Residential building megaproject duration



Commercial and leisure megaproject duration



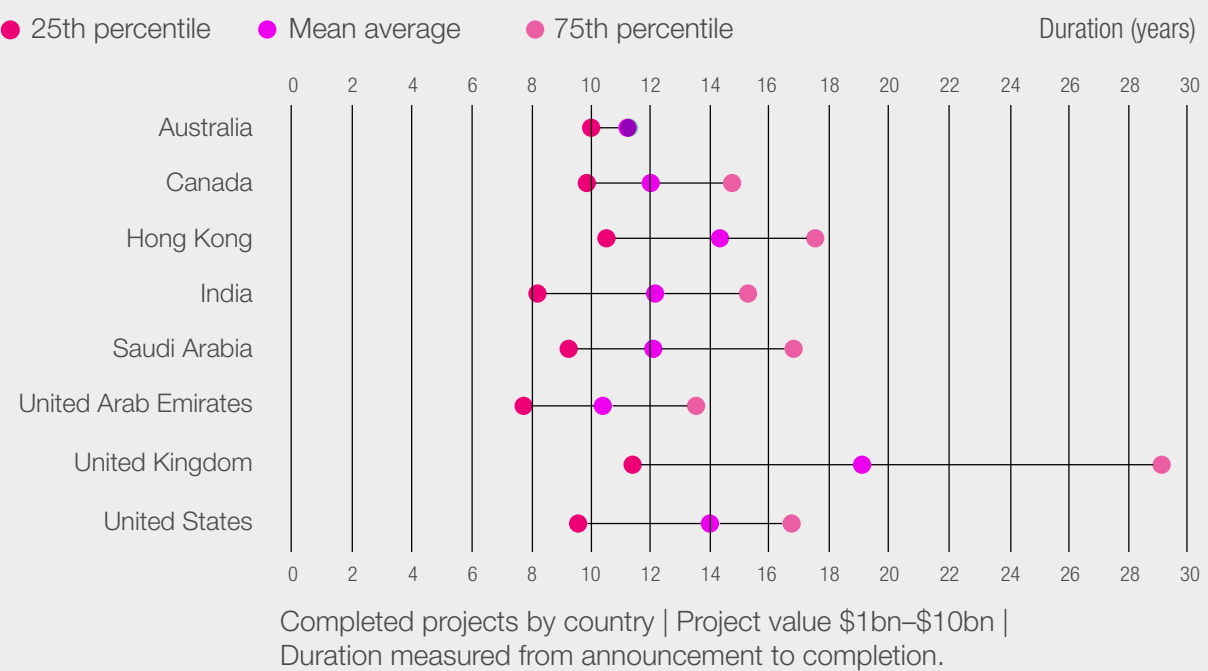
Interestingly, when we look to commercial and leisure project delivery performance, the general trends we have seen thus far reverse, with the UAE and Hong Kong being generally slower and the US and UK leading the world in delivery. As with residential projects, one difference also may reflect the scale of buildings in the UAE.

For example, the Expo 2020 program in Dubai was inclusive of six million square meters and at the peak of construction, had a workforce of 30,000. Projects of such scale invariably run longer.

Perhaps more than any other sector, commercial and leisure programs were stalled during the Covid-19 pandemic, with

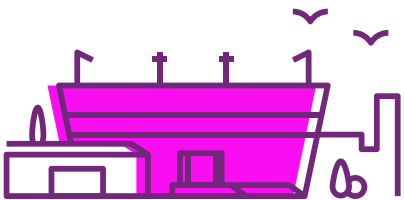
openings and operations delayed for a year or more around the globe as a result of health, safety and workforce constraints.

Infrastructure megaproject duration



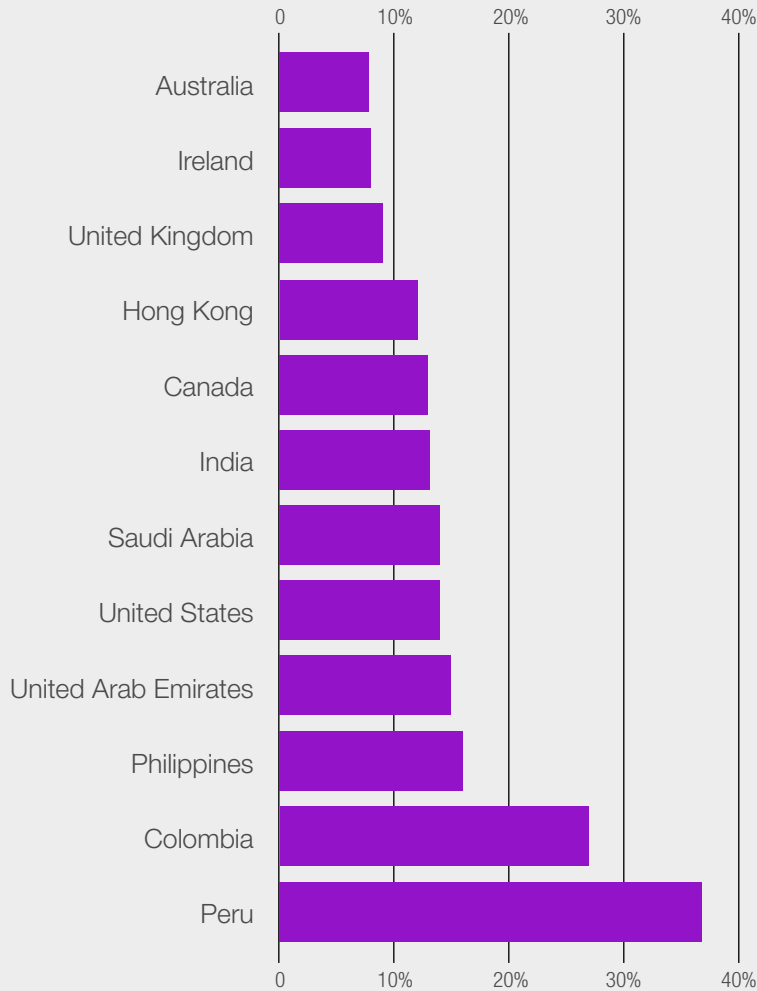
When it comes to the infrastructure sector, the spread in the UK's program duration data shows a marked difference from the rest of the world. This largely reflects systemic issues that sit outside the control of those responsible for delivering infrastructure, but it also creates a challenging operating environment for industry providers.

An excessively bureaucratic planning process is chief among the barriers to expeditious delivery, while shifts in political backing for some of the nation's biggest programs in recent years have created a sense of uncertainty about funding and costs risks associated with project delays.



On-hold/inactive

Percentage of projects announced since 2010 that have become inactive or put on-hold.



Source: Bradshaw Advisory analysis of the GlobalData Construction Projects Database for Mace. Analysis based on 637 global megaprojects (> \$1bn) declared on-hold or inactive from 2010-2025, filtered by geography, project stage and recency of updates.

Projects on pause

A proportion of megaprojects and giga-programs and ultimately stall, with many placed ‘on hold’ or becoming inactive at various stages of development due to poorly defined scope and inadequate budgets being influenced at the outset to get them through the approvals process. Our analysis shows that a stop-start approach does create a significant impact. Where projects and programs experience particularly high rates of delay, uncertainty can cause ripple effects dampening investor confidence, as well as hindering the supply chain’s ability to sustain investments in essential skills and innovation.

Peru and Colombia have the highest proportions of stalled projects since 2010, with over 30% and 25% respectively declared on hold or inactive. These elevated rates typically reflect underlying issues such as historic political volatility, financial pressures or limited institutional capacity to sustain complex, capital-intensive projects.

Both countries are taking action to overcome this issue, however. One way is through government to government (G2G) agreements – collaborative arrangements that draw on international support and expertise to secure financing and enhance local delivery capability. Mace has been at the center of such G2G efforts in

Peru, as outlined in our case study on page 23.

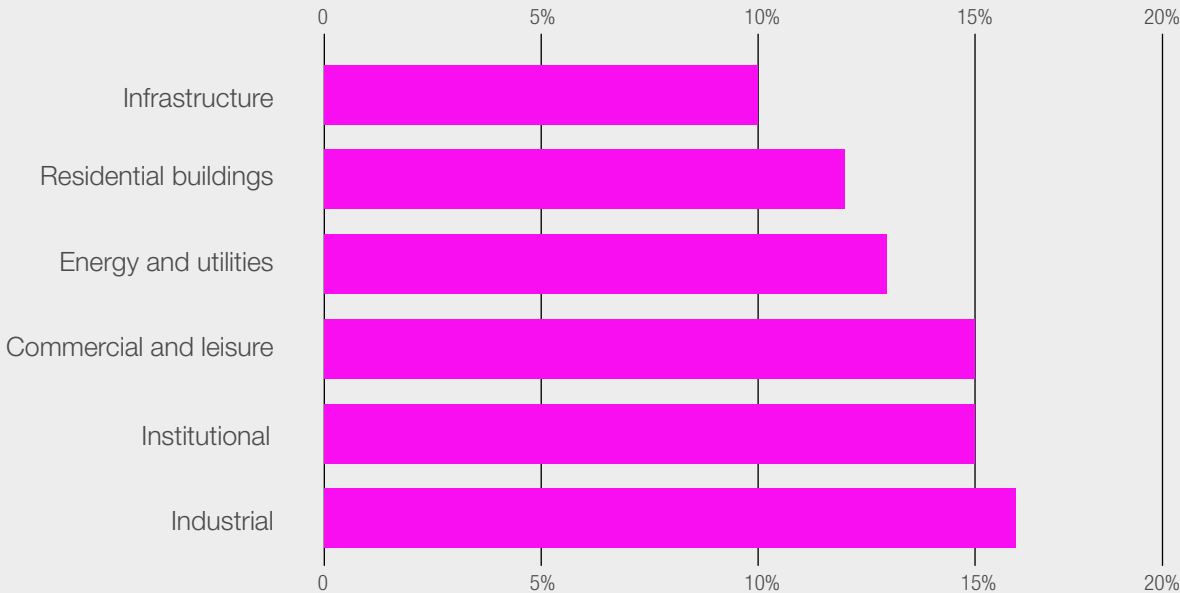
There are noticeable variations in sectors revealed by the data. Industrial, institutional and commercial developments were found more subject to change or delayed to become inactive.

In contrast, infrastructure programs, while exposed to

political and planning risks, appear more likely to see a continued commitment to completion, but are much slower in delivery versus privately funded industrial and commercial projects.

On-hold/inactive

Total of projects announced since 2010 that have become inactive or put on-hold by sector.



Source: Bradshaw Advisory analysis of the GlobalData Construction Projects Database for Mace. Analysis based on 637 global megaprojects (> \$1bn), declared on-hold or inactive after announcement from 2010-2025, filtered by geography, project stage and recency of updates.

Getting a sense of what lies ahead

While many studies have looked retrospectively at finished projects to assess delays and cost overruns, we wanted to consider the risk of notable delay to megaprojects and giga-programs that are yet to be completed.

To do so, we used a bespoke AI research tool that looked at publicly available information relating to our database of more than 5,000 projects and programs, and used a set of key word indicators to understand the sentiment involved around their delivery. As with any modeling, the findings present an interpretation of the situation. Further information on this methodology can be found in the Appendix.

Our analysis of a sample of 5,330 megaprojects and giga-programs across 12 locations indicates that...

11% are at risk of significant delay.

Our research also shows variation in the risk levels across different geographies and sectors.

But, before we look at some of the findings, we should reiterate the importance of clear and accurate baselines when setting expectations. While change is an inevitability (as we discuss later), the reality is that baselines often frame success criteria for major program delivery, especially in the eyes of politicians and the public. Early certainty of outcomes informs benchmarking, which allows for realistic baselines that coordinate scope, time, cost, quality and safety.

While the 11% of programs at risk of significant delay reflects a more complex issue than just getting the baseline right, it does represent a fundamental stage upon which all future milestones will be assessed. So, a failure to align baselines on major programs, which often happens when there isn't coordinating partner fully informed with visibility to manage across work streams, raises the question of whether schedules are truly delayed, or

unrealistic from the outset.

Our data provides some useful reflection points. While efforts are being made to strengthen the pipeline and boost industry confidence, in nations that are still maturing delivery capabilities, such as Peru and Colombia, major programs continue to face higher chance of delays, with over 20% at risk. As local supply chains gain experience in programs under way, like those in Peru under G2G agreements, where successes like the Lima Pan American Games, the National Infrastructure Authority's Reconstruction and Resilience Program, and the Peruvian Education Ministry's Bicentennial Schools Program bolster confidence by progressing effective delivery.

For example, government authorities note that the G2G partnerships for programs in Peru helped to deliver critical projects in just a fraction of the time normally taken, such as education and healthcare facilities that previously took 3-4 years longer to complete than those delivered via G2G partnerships.

In contrast, locations such as Ireland, Hong Kong and the United States, which are more mature in their delivery of major programs, showed notably lower risk rates, with fewer than 10% of projects flagged by the algorithm. The reasons for this are likely to be varied.

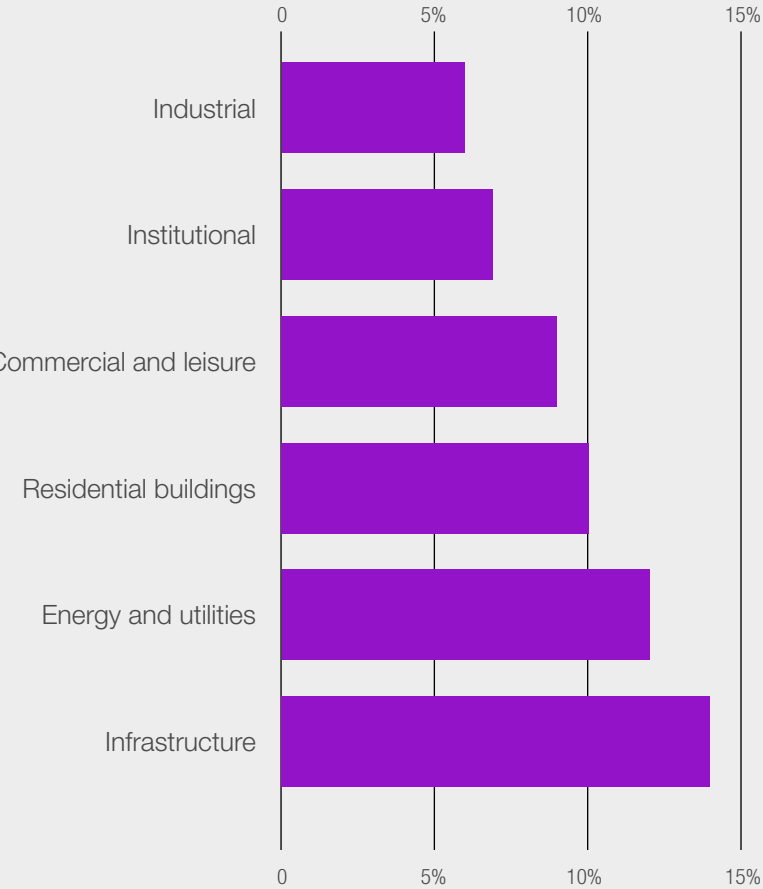
In Ireland, a smaller and seemingly more achievable pipeline, along with a mature approach to collaborative delivery models, could be underpinning this confidence.

In Hong Kong, careful coordination of the pipeline by the Government, combined with a small geographic area, improve certainty.

The US, on the other hand, has a huge pipeline and vast expanse, yet performs well despite added complexity from varied and sometimes conflicting state, local and federal regulations. The effectiveness evident in the US largely reflects mega capital projects led by private-sector industrial companies and those at US federal bases, many of which use progressive design-build and other collaborative delivery methods.

Risk of significant delay

Percentage of projects flagged as having evidence of a significant risk vs. no evidence of significant risk.



Source: Bradshaw Advisory analysis of the GlobalData Projects Database for Mace. Analysis based on 5,330 global megaprojects (>\$1bn), filtered by geography, project stage and recency of updates. 'Megaprojects' include giga-projects.

When we look at sectors across the globe, infrastructure projects and programs reflect the greatest exposure to risk, with nearly 15% showing evidence of delayed delivery. This was followed by energy and utilities, and then major residential programs. In contrast, industrial and institutional projects were the least likely to be flagged for risk, both with levels below 7%.

These findings suggest that geography and sector both play an important role influencing delivery risk, with large-scale infrastructure and energy investments particularly vulnerable in certain emerging markets.

What's important to remember with all of these data points and considerations is that none of them are black and white. For example, longer program duration is not necessarily an indication of poor delivery performance, and often can

reflect underlying political structures. It also can reflect sheer scale or complexity, or a blend of some or all of these factors. The reality is, whatever the sector or place, nobody gets absolutely everything right. Part of our response to risk should be looking at major programs as learning opportunities, where industry practitioners commit to taking lessons (good and bad) into account and action on future commissions.

In essence, this is about creating an industry culture where everyone sees and shares responsibility to improve delivery performance.

In turn, this can encourage authorities to seek more coordinated solutions and collaborations of owners, program managers and supply chains to help navigate pitfalls across the complicated ecosystem of megaprojects, starting from the beginning.

Many of the biggest challenges stem from misaligned baseline scopes and, to address them, requires integration of schedules across work streams and, importantly, a realistic reflection of the myriad, dynamic factors known to affect delivery. Establishing a well-thought-out scope grounded in realistic terms gives teams the best chance of delivering on-time which, in many ways, matters most. Because when a program is afforded appropriate, realistic consideration enabling on-time delivery, other performance measures like cost, quality and safety also are likely to follow. It is why we so commonly hear of success stories on major programs tied to events – the specificity of event dates sharpen focus.

Having looked at the number, types and spread of mega and giga-programs and projects, as well as how performance varies via geography and sector, the report now goes on to look at delivery models being used around the world, as well as some of the barriers to effective delivery and what we consider to be the solutions.



Transferring knowledge

The Lima 2019 Pan American and Parapan American Games marked a significant milestone for Peru, showcasing the nation's capability to host a major international sporting event.

The Games hosted over 8,500 athletes from 41 countries, enhancing Lima's global reputation (especially within the Americas) and served as a catalyst for investment in the city. It also acted as a 'blueprint' for further major program delivery. Central to this achievement was the involvement of the UK Delivery Team (UKDT), a consortium led by Mace in collaboration with Arup and 4global.

The team brought significant experience from the London 2012 Olympic Games around collaborative working, Incentivization, supply-chain management, PMO and risk management. UKDT had responsibility for the overarching delivery strategy for the core permanent venue infrastructure, establishing and

implementing an integrated program management office function, and supporting the delivery of the venues. UKDT's efforts were instrumental in the successful completion of five world-class venue clusters and a new Athletes' Village, spanning 44 hectares and providing 1,100 apartments.

Beyond economic benefits, the Games left a lasting social legacy for the local community, supply chain partners and the government. The venues developed are accessible and resilient, ensuring their long-term utility for the community. The Athletes' Village has transitioned into housing for local residents, contributing to the social fabric of the Villa El Salvador district.

The UKDT introduced modern procurement and contracting

practices—such as the use of collaborative contract models, streamlined digital platforms and sensible risk management—which helped to reduce the time to mobilize. They also aligned the team to the key project outcome: delivering the games venues on-time. The approach shifted how Peru plans, builds, and manages its public infrastructure.

From that success came a comprehensive, nationwide program to re-build and bolster the resilience of critical infrastructure in Peru, with 140 projects mitigating devastation wrought by the El Niño floods since 2017.

The Peruvian government entered into an agreement to dispatch a team of Mace, Arup and Gleeds to provide program management and technical support to deliver the National Infrastructure Authority (ANIN) reconstruction program.

The team built on the experience of the Pan American Games to deliver a large-scale, climate-resilient infrastructure program serving millions of Peruvians, while also building local capabilities with knowledge transfer, digital tools and

development with local stakeholders to leave a legacy of value and opportunity.

Over the course of the partnership, the team has supported the planning, procurement, and delivery of 74 new and retrofitted schools, 18 healthcare facilities, and extensive flood protection infrastructure across 17 river basins and seven cities.

In many cases, delivery timelines were reduced in comparison with similar projects undertaken in Peru, with schools completed up to three years faster and healthcare facilities delivered four years ahead of the norm. This reflects the benefit of extensive formal and informal training provided for more than 16,000 people across 100 organizations as part of the program, including executive education on NEC contracts designed to equip Peru's infrastructure leaders with the tools and capabilities to successfully deliver future programs. Such training helped to develop local talent while promoting domestic ownership and partnership to sustain and build on the infrastructure improvements.

Megaproject delivery in Peru

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We put together a team from different origins and different backgrounds to create the 'Lima Team' that brought a much more efficient way of doing things.

— Carlos Neuhaus,
President of Lima 2019 Games

I'm hugely proud of what has been achieved for and with the people of Peru: The faster delivery of better, and more sustainable infrastructure.

— Gavin Cook,
UK Ambassador to Peru

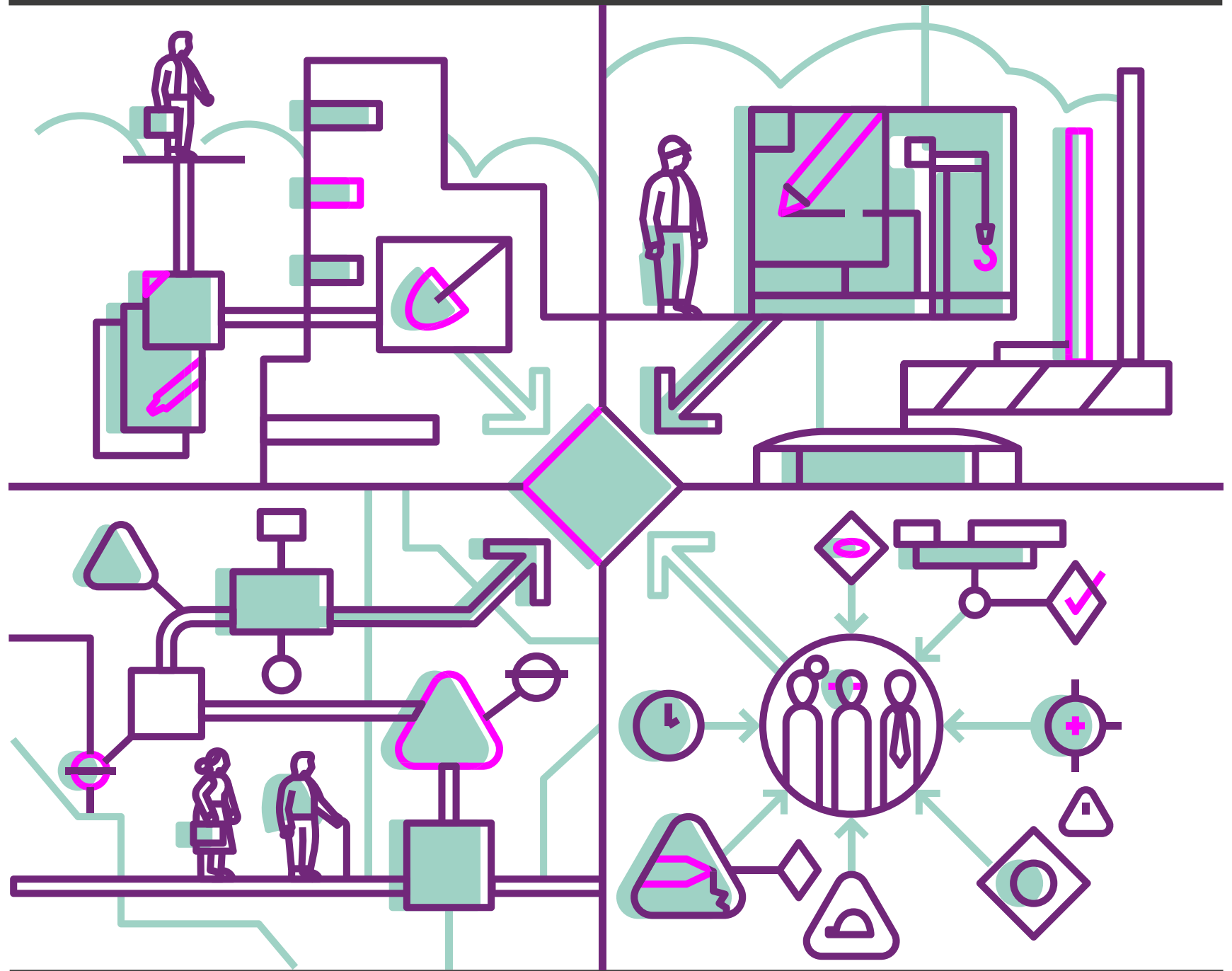
Together, we are delivering urgently needed infrastructure to international quality standards and demonstrating the best way to deliver major projects for a safer and more prosperous Peru.

— Hernán Yaipén
Director of the Peru
National Infrastructure Authority

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The value of clear governance and collaboration

3



The value of clear governance and collaboration

Around the world, there are several different approaches to program and project delivery. The chosen method often reflects a blend of regional and cultural preferences, specific sector needs, the scale of the commission, how complex or unusual it is, the past experience of those involved, the capability and capacity of the client and the nature of the risk.

To manage projects and programs of scale requires establishment of clear governance to empower teams and decision making with well-defined guidelines for various contract types. Design and build might be selected as an appropriate delivery mechanism for projects of lower complexity, while, in oil and gas, the Engineering, Procurement, and Construction (EPC) approach is common. Depending on geography, water infrastructure programs often use progressive design-build as a collaborative alternative to conventional mechanisms like design-bid-build contracts.

Looking at a specific water sector example in the UK, the use of an alliancing approach by Anglian Water has been used repeatedly to enable consistent out-performance of the targets set in its capital development plan, according to a case study developed by the Institution of Civil Engineers^{xv}. It is a model valued elsewhere in the country, with Melissa Dudley, Deputy Director for the Ministry of Justice's program focused on prison capacity,

highlighting the value she sees in the model. When asked about the core principles that underpin a successful alliance, she said, "it's everyone having skin in the game for each other's success", before adding that this typically sees all team members "driving toward the same outcome, leaving their organizational badges at the door and upskilling each other collectively to deliver a common outcome."

Other collaborative models include Construction Manager at Risk, Integrated Design-Build, and Integrated Program Delivery.

As contracting preferences continue to evolve, the delivery partner model has emerged as one of the most effective approaches for projects and programs in the mega and gigatiers due to its integrated, end-to-end management across all elements and phases of the lifecycle. Taking a very literal view of the word 'partner', this approach promotes a unified team culture, with aligned governance, goals, agreed outcomes and mechanisms to fairly share risk

and reward opportunities among parties involved, so the client's vision is fully supported.

Regardless of the specific model chosen, wherever a project or program falls on the spectrum of mega and gigascale, the clarity of scope or degree of complexity, an approach that centers on true collaboration has certainly been proven as the best path to effective delivery.

Increasing complexity and scale also are driving more collaborative approaches when it comes to financing. With public purses squeezed in many parts of the world, innovative public-private

partnerships (P3s) and intergovernmental investment agreements are becoming increasingly important to bring large-scale projects to fruition. Design-build finance and operate (DBFO) contracts are becoming more common.

Certainly, it was clear from interviews conducted for this report that collaboration and building trusted partnerships are seen as central to the delivery of large-scale projects, programs and capital portfolio plans. This is backed by academic research into the benefits of collaborative delivery models for time, quality and cost measures.



We are looking at framework contracts, we are looking at other collaborative forms, so that good contractors can work with us for longer and build lasting relationships.

—John Kwong,
Vice President for Development,
The Hong Kong University
of Science and Technology



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Really powerful delivery partners are those who truly, truly own the mission with you, almost more than you.

—Toufic Machnouk,
Managing Director, GBRX

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“Appointing a program delivery partner is a key part of the response to the resourcing challenge, because then we have much easier access to the kind of capabilities we need.”

—Program Director,
Energy and Utilities
Sectors, UK

“Projects are team games, so collaboration is critical. Spend the time building relationships.”

—Senior Director,
Water Sector, UK

“To have confidence in a program, I need to see the budget, the bill of quantities, and the schedule. Without continuous visibility into these, it’s difficult to find the delivery partner credible.”

—Atif Ansar,
Executive Chairman and Co-
Founder, Foresight Works

“The delivery partner becomes an extension of the client, but importantly they know the market well, they know how to package work, they are responsible for procurement, then they have to integrate and deliver it.”

—Andy Haynes, Commercial
Director, Delivery Authority
for the Restoration and
Renewal of Parliament

“When you do a megaproject, you have to look at contractors and consultants as your partners. Genuinely as your partners, so the contract needs to be in the favor of both.”

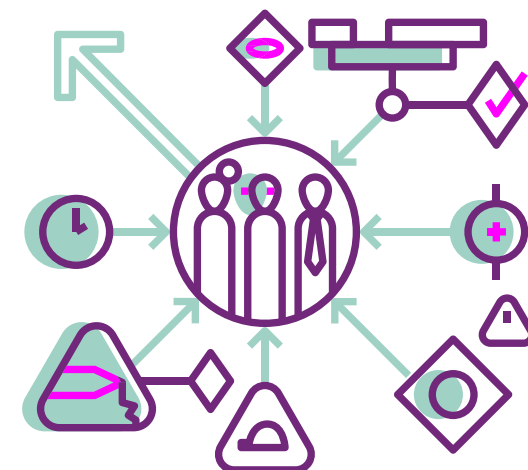
—Ahmed Al Khatib, Chief Development and Delivery Officer
Expo 2020 and Expo City Dubai, UAE

Over the last 10 years there have been academic studies comparing more collaborative delivery approaches to traditional and transactional ones, and their conclusions concur that collaborative models significantly improve cost, schedule and societal outcomes on major projects and programs.

In terms of megaproject budgets, collaborative approaches were found to reduce costs by a range of 4-13%^{xvi,xvii} compared with those delivered via traditional disjointed models. In terms of on-time delivery, a study in Australia found that a collaborative approach more

than doubled the chances of on-time delivery, while reducing overall timeframes by 36-78%^{xviii,xix}.

While collaborative delivery models are not a cure-all for megaproject risks, when applied properly and managed well, with full buy-in of involved parties, results are impressive, with projects coming in on- or below-budget, finishing on-time or ahead of schedule, while achieving greater long-term benefits. The London 2012 Olympics, Peruvian partnerships and Metrolinx case studies herein all stand as collaborative delivery examples achieving superior performance and outcomes.



Barriers to a brighter future

4



Barriers to a brighter future

The reasons megaprojects spiral out of control in costs and delivery timelines are multi-faceted, and one issue can cause broader ripple effects. Our interviews with more than 30 industry professionals across the globe highlight a number of common risks that lead them astray.

The findings below reflect the most frequent and consistent issues cited in our research.

“There is pressure to show progress. This is most acute in projects of interest to politicians with short-term agendas. Many start before designs are complete and people are actually sure what the end product should be. And often, money is released in a way that incentivizes such behavior.”

—Senior Executive, Rail Sector, North America

Starting too quickly

The majority of experts we interviewed noted the desire to get ‘spades in the ground’ as soon as possible as a way to demonstrate timely delivery. More troubling is pressure to accelerate the commencement of major programs so policy-makers have ‘ribbons to cut’, in the words of one interviewee. To be sure, politicians looking to score points with their constituents have been known to push pet projects forward based on election timing. This can result in premature action driven by unwarranted urgency,

sometimes before construction works are anywhere close to being ready to go. Even the Thames Tideway Tunnel in London—completed in 2025 after ten years of construction and generally regarded as a delivery success—was subject to scrutiny for how its early options appraisal was done, with critics arguing that decisions were rushed and driven in part by the desire to to promote the very large undertaking as a highly visible public show of action^{xx}.

Supporting the notion of taking time to get delivery right is analysis by the UK’s Construction Leadership Council^{xxi} of 20,000 projects, which found that those with the best planning from the outset had 20% lower costs and were delivered up to 15% faster.

Not allowing adequate time for thorough consideration at early project stages, in pursuit of a ‘quick fix’ instead, is not only a false economy; worse, it can snowball into a bigger series of problems emanating from a flawed baseline, ultimately influencing poor decisions that may hamper efficiency, the opportunity to innovate, and

the ability to acknowledge and respond to challenges throughout the duration of the lifecycle. Along with risks to delivery, this unnecessarily skews the assessment of a program’s performance and places the project team under unreasonable pressure.

Taking the time early on to establish a clear and rational baseline is invaluable. Aligning scope with time, cost, quality and safety is essential to set realistic goals and avoid surprises. A realistic baseline enables a factual evaluation of true performance and improves the ability to recognize and address real versus perceived risks, while also enabling realization of improvements.

London 2012 and the Marina Bay Sands in Singapore are project examples that got baselines right. In both instances, governance played a central role to ensure scopes were well-defined, so teams clearly understood everything required to achieve outcomes envisioned, including risks they needed to manage. Both were delivered ahead of plan and continue to deliver greater value to their communities.

“Plans are best-case scenarios. They ignore what usually happens.”

—Nobel Prize winning psychologist, Daniel Kahneman

“What we tend to do on large projects is go in with an overly optimistic position on costs which are often founded more on hopes than on true facts.”

—Managing Director, Rail Sector, UK

Too much optimism

Throughout the course of history, optimism about the future has propelled human progress. And, for better or worse, it sometimes inspires people to conclude that the risk is worth the reward. After all, nothing bold is accomplished without some degree of chance.

However, for all of the positives of a ‘can-do’ attitude, there’s a difference between taking a carefully considered, calculated risk and blind optimism ignoring it. The tendency toward optimism has been shown to have a negative impact on the delivery of capital projects, all the more visible and prone to amplification for those of mega- and giga-scale.

In 1979, the pioneering psychologist, Amos Tversky, identified the ‘planning fallacy’ as a systematic cognitive bias that gives humans the tendency to underestimate the time, costs, and risks of future actions while overestimating the benefits.

In combination with that bias, Tversky’s academic collaborator, Daniel Kahneman, identified the ‘inside view’ as the propensity of people to focus on their current project while ignoring past, similar projects offering resulting turnout data. Together, these contribute to ‘optimism bias’.

To combat this issue, the UK Government developed guidance (contained within the HM Treasury Green Book) to provide fact-based rigor for project baselines and estimates. The approach includes adjusting estimated costs upward for a program based on reference class forecasting (that is, benchmarking the project against similar ones that have been completed) in an effort to ground forward-looking estimates in relevant, real-world historic data.

“I’ve often seen over reliance on what a cost consultant tells a project, and this has created tense situations and arguments. The market will tell you much more accurately what it costs to build and cost consultants are only able to do this when the design and scope are developed enough.”

— Executive Director, Major Programs, Middle East

Misusing cost consultants

There was consensus across interviews that the work of cost consultants is often compromised by inaccurate or incomplete data – especially when early-stage estimates are produced before designs are complete, or proper validation and constructability reviews have been conducted.

In fundamental fashion, cost consultants are brought in to provide owners reasoned cost projections to deliver plans as documented. This is done through estimating quantities and costs and multiplying the two together, including risk and contingency factors.

While these estimates can be useful in setting an initial

range of expected costs based on known parameters, they should not be misunderstood as accounting for unknown quantities or information gaps associated with a program. Only once detailed designs and constructability reviews are completed with input from contractors, can realistic estimates be framed. And even at that stage, such cost estimates should be understood as informed but inexact assessments, preferably provided as ranges to account for uncertainties and contingencies made necessary by changing market dynamics affect the course of delivery over the program’s lifecycle (e.g. inflation, trade tariffs and resourcing risks).

“At its heart, cost consultancy is the art of knowing change will happen and baking that in at the outset with a correct risk and contingency mindset.”

— Ceri Evans, Global Director for Cost and Commercial Management, Mace

Since many infrastructure megaprojects are publicly funded, they commonly come

under political and media scrutiny, and this can make them subject to pressure to meet more precise, exacting estimates of costs and delivery times than can be assessed up-front, in practice, contributing to unrealistic expectations potentially counterproductive to success.

To progress projects from an initial concept there is normally a formal approval requirement that sets a bar for performance as a ‘hurdle rate’ that must be met, or a cost-benefit ratio to be achieved. Such measures often involve highly sensitive calculations, wherein a small change in just one variable or an assumption can produce dramatically different results in the actual performance realized upon execution.

Hong Kong has moved to a system of ‘reference class forecasting’ to improve performance predictability— via a database of similar, completed projects providing reference data applied to derive new project estimates. This top-driven approach, rather than bottom-up forecasting, has been proven to result in more accurate cost and time estimates.

One case study of the Australian State Road Authority conducted by the Project Management Institute^{xvii} showed that an approach that included reference class forecasting halved the estimation margin of error in final costs.

Transactional relationships

Many large-scale programs are divided into phases of work with different partners, varied contract types and sometimes, with different operating units or leaders within the client/owner organization. While, of course, you need the right people with the right experience at the right time for successful delivery, it is important to mitigate any potential breaks in continuity to sustain performance measures and incentives; as such disconnects are common root causes of delivery failures. In addition to changes (personnel or otherwise) within program organizations, many large projects also must contend with changes in the market landscape that can affect their performance and outcomes, such as shifting political priorities or workforce and supply chain developments

affecting the ability to achieve budget and schedule targets.

Moreover, at different stages of the lifecycle, programs commonly involve multiple participants with different backgrounds and views, from advisors, to designers, to engineers, to project managers, to contractors and suppliers. If these parties co-exist independently without common focus or continuity, and each takes the view that ‘I’ll just look after my phase, let others fix what comes later’, such gaps can create larger ripple effects subsequently resulting in more significant shortfalls down the line.

“In my experience, the projects that worked were the ones where the client knew what they wanted and were clear about it. The ones that didn’t work were the ones where the client didn’t really know what they wanted or the direction of the project changed without anyone dealing with it.”

— Andy Haynes, Commercial Director, Delivery Authority for the Restoration and Renewal of Parliament

A lack of clarity

Our research and interviews show that some mega and giga-programs and projects are set up for failure because they lack common understanding, causality and clarity about the outcomes they are meant to deliver. The most important part of any project is having a clear and shared understanding of the problem you are trying to solve and how the work being performed will help achieve that solution.

Despite the stakes, many megaprojects are not set up in this way. And even when outcomes are clearly articulated and understood, they're still bound to meet challenges and conflicts that only well-defined governance, cohesive management, carefully attended culture and practical experience can overcome. Such provisions enable collaborative problem solving, negotiation of trade-offs, and focused, agile execution to keep them on-track.

Scarcity of experience

The increasing number and size of major projects places substantial demand on the

workforce required to deliver them. From front-line workers and technical specialists to managerial ranks, the volume of talent possessing substantive experience required to deliver large-scale programs is a relatively small population, with intense competition placing a high premium on experience. From our interviews, this concern is especially acute among senior ranks, with a belief that only a handful of project directors possess significant and relevant experience delivering to mega, let alone, giga scale.

The limited supply of experienced professionals with the right capabilities (and availability) to steward an increasing number of megaprojects makes it especially challenging for public sector entities that cannot match pay scales offered by private sector companies investing in capital programs. Middle Eastern locales also face discontinuity challenges as expatriates work for abbreviated periods due to personal taxes. This not only interrupts management continuity; it makes it difficult to develop native capabilities.

The staffing required to deliver megaprojects can be larger than the employment numbers of many companies. Several experts we interviewed noted that people and organizational management skills required of today's project leaders are quite different from those of 20 years ago, such as addressing resistance to change and fostering a learning mindset for continuous improvement. Even the most technically competent managers may struggle to adapt to new ways of working and cultural differences.

This is why effective engagement and team building are especially important to successful delivery. People skills are central and essential to all project management roles.

We've found that disciplines like change management, leadership skills, culture assessment and organizational development are among the most important capabilities for successful delivery. This goes for all levels of the client organization, project team and partners, governing bodies, executives, middle managers, front-line supervisors and operations management.

It's a challenge getting more attention in our industry, and being put into practice more broadly. The UK's 2025 Industrial Strategy is one example to build management capabilities through a global drive to develop "top tier managerial and engineering talent" to support growth-driving sectors^{xxxii}.

"Trust is the bedrock of any good business. Without it, it is very difficult to deliver or succeed"

— Warren Kencroft, Vice President, Technical Integration, GO Expansion

Trust issues

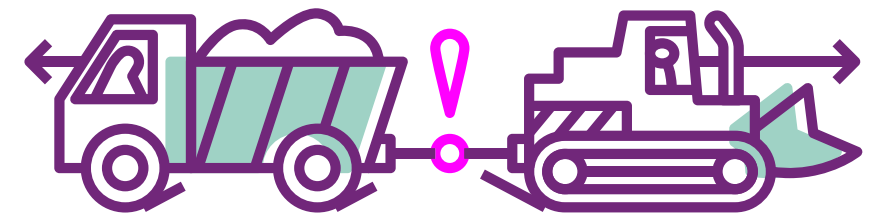
To build relationships enabling effective delivery throughout megaproject ecosystems, earned trust is the most valuable commodity; it takes time but pays dividends for success by unlocking empowerment, appreciation, collaboration and transparency. Trust is like equity; it conveys confidence. When you build it up, it can see you through difficult times, but once lost, it's much harder to recover, let alone to align and inspire teams to give their best performance when trust is lacking.

The fundamental problem with disjointed contracting models and their transactional relationships comes down to a deficiency of trust. And poor governance, whether by absence or over-complication, limited access to clear and transparent information. That's the recipe for distrust.

Pulling in different directions

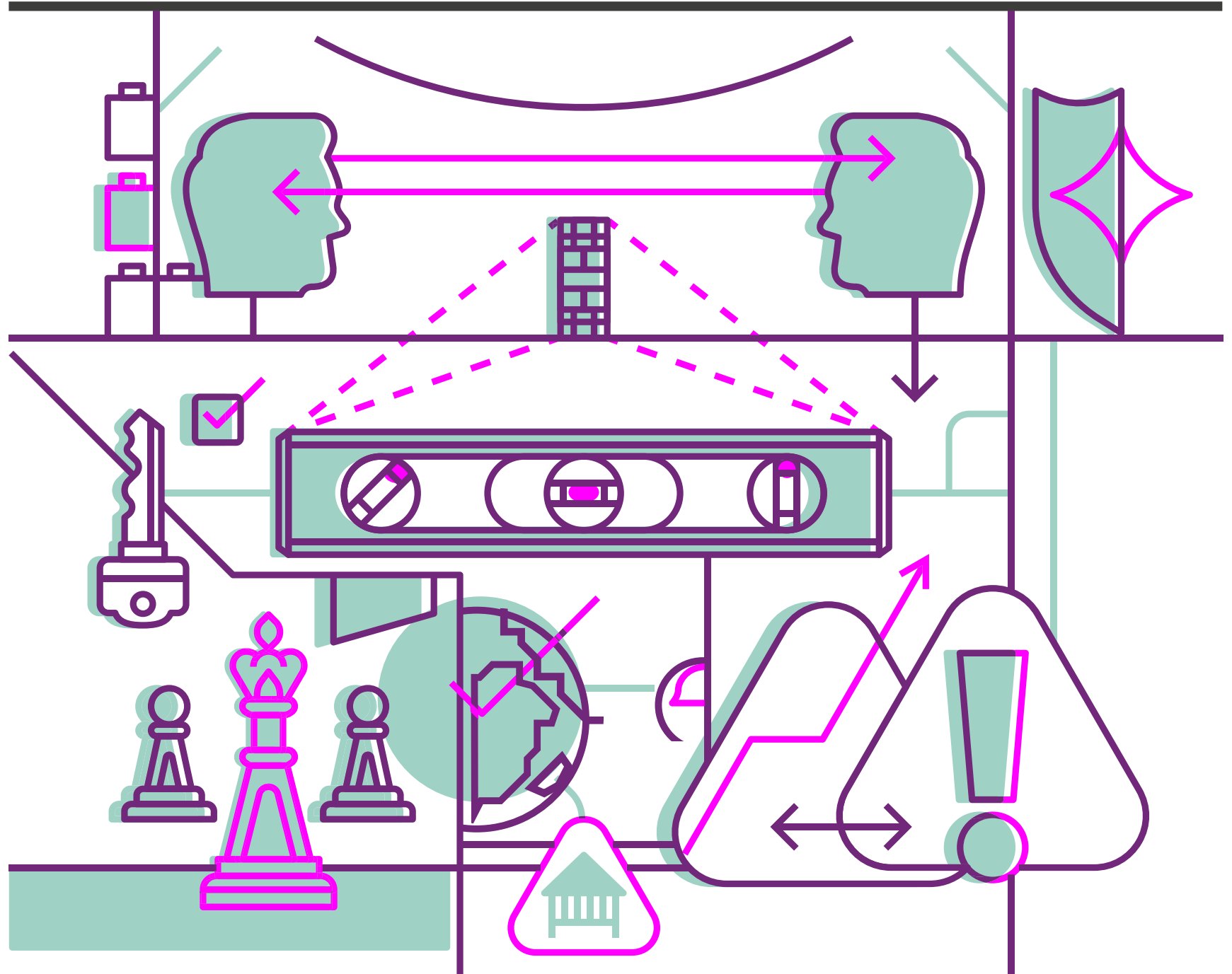
Without the integrity of transparent objectives, the parties involved in various aspects of delivery are more likely to pull in different directions for their own interests than they are to pull together for the project's interests. Misaligned people, organizations and performance measures make fertile ground for conflicts and claims. And for programs of scale, that's a recipe for disaster.

A further complication we note is that megaprojects often span multiple jurisdictions – sometimes with conflicting requirements. In these instances, work packages and interdependences are subject to greater risk of breakdowns and missed 'handoffs' between project areas, phases, and supply chains performing tasks. Interactions and interdependencies involving project parties and stakeholders can present significant challenges if not managed in concert to prevent breaks. Since large-scale programs generate complex webs of issues and interfaces, it's also important to build trust and understanding among them to bridge gaps and work through entanglements that otherwise can impede delivery.



Ten pillars of successful collaborative delivery

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Ten pillars of successful collaborative delivery

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Collaborative delivery unlocks maximum value when there is true alignment at every level. In practice, this means clients, consultants and contractors – from senior leadership to day-one apprentices – unifying behind shared visions, objectives and culture to work together towards the same desired outcomes. Knowing that success is shared, as is failure, sets expectations, guides decisions, sharpens focus and, ultimately, raises performance.

—Davendra Dabasia, Chief Executive Officer, Consult, Mace



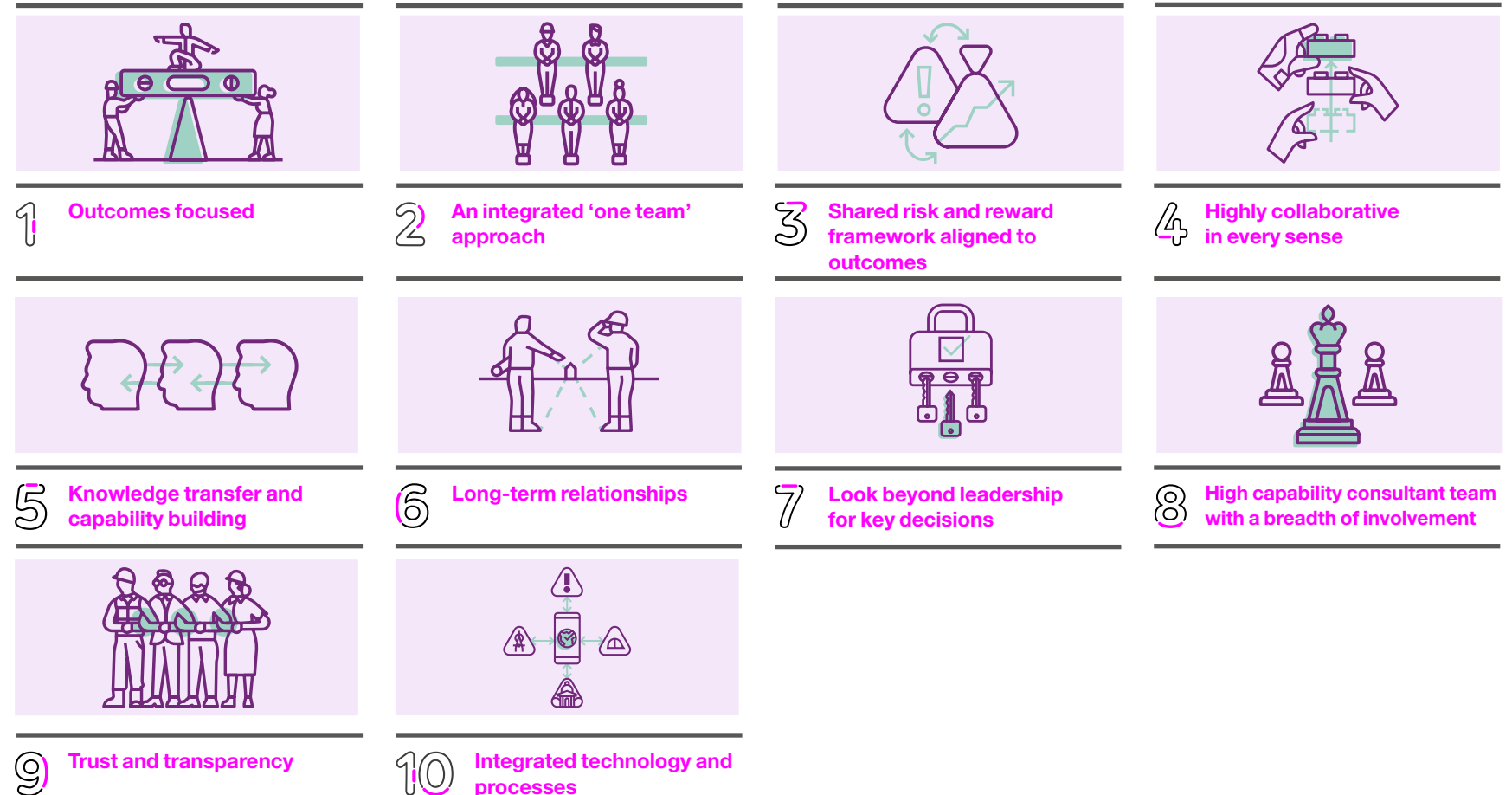
Around the world, increasingly complex megaprojects and giga-programs struggle to meet global demand for talent and commonly exceed their budgets, are delivered late, and under-delivering on benefits.

In our view, a big part of the solution to these problems

starts with a discipline of collaborative management built on relationships of trust, and sustained throughout program lifecycles, with clients, consultant partners, contractors and the wider supply chain all aligned around common goals and shared vision. Much of what we

include here has been informed by our experience fostering collaborative approaches with clients, including the delivery partner model, to achieve benchmark performance and outcomes on mega- and giga-scale projects. With extensive examination into why so many programs of scale fail to realize

outcomes desired, we've identified ten "pillars" of collaborative delivery. While each has its own merits for megaproject and program management, taken together, they provide the strongest possible foundation for successful delivery:



One

Outcomes focused

Before embarking on any project or program, the entire team needs to be crystal clear about the key outcomes desired.

Outcomes that go beyond the physical asset, emphasizing positive change while also embedding a lasting legacy of community benefits, should underpin every large-scale project or program. From the start, clarity and focus on outcomes rather than outputs form the basis for alignment of stakeholders and project teams around common interests, and in turn, the prioritizing the best project interests. An outcomes-focused mindset guides measured decision-making rooted in common purpose.

So, if the aim of a capital plan is to improve mobility within a city to enhance public access to services and opportunities, leaders may decide to optimize

access, efficiency and inter-connectivity across various transit modes their local constituents already use, such as light rail, bus, ferry and bike routes, leading them to invest in technology and infrastructure improvements that streamline travel times and transfers between modes.

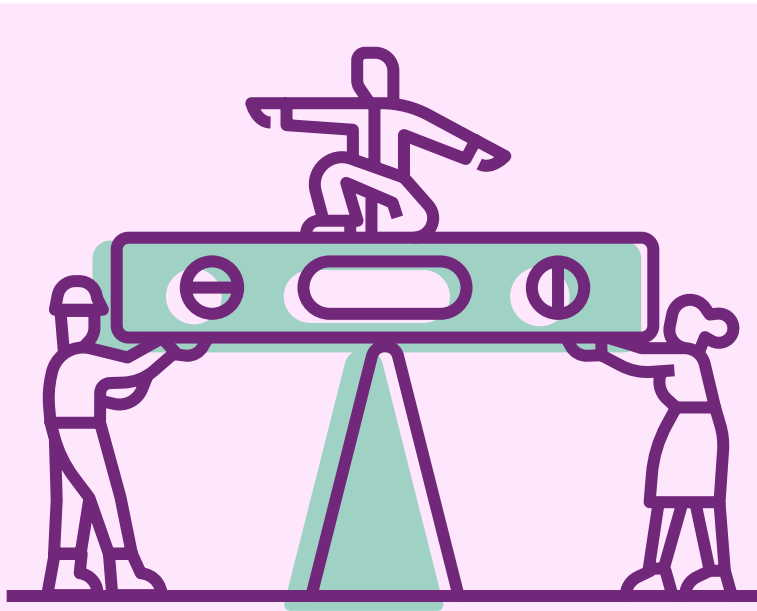
Rather, if the aim is to enhance connectivity within and between cities to improve productivity, safety and relieve congestion, leaders might look to optimize inner- and inter-city rail transit.

The point being that the first order of megaproject success is clarity, with causality assuring the program conceived is set to deliver the outcomes intended.

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If you're not completely clear and aligned on outcomes and objectives then that can cause you a lot of problems. Projects spend a relatively small amount of time and expenditure before they get into the construction phase, but that pre-construction time is often the most critical. Once you've committed to a contractor and start building, that's when the big spend comes.

— Peter Hurst, Executive Director for Singapore and Hong Kong, Consult, Mace



Starting with outcomes

Many large projects around the world start their journeys and even begin delivery without clarity of the key outcomes the capital plan is looking to achieve. And, if project leaders fail to prioritize multiple outcomes, it becomes nearly impossible to effectively weigh trade-offs or compromises.

Amazon, the world's fourth-largest company by market capitalization, focuses acutely on outcomes from the outset of any business or capital consideration. The company 'works backwards' from the traditional project endpoint.

Amazon brings the work backwards method to life by requiring teams to draft a mock press release and frequently asked questions (FAQs) for proposed products to articulate outcomes in advance.

Instead of starting with technical specifications, the drafts describe results of the finished product as if it were launched to market, with

responses to anticipated FAQs from internal and external stakeholders.

This serves to vet and validate the business case and expected outcomes upfront, ahead of the decision to invest in the product or program proposed.

The documents must precisely outline outcomes such as customer benefits, problems solved, and improvements afforded in clear, non-technical terms, starting with a one-page news announcement that leads with headlines most important to stakeholders, and further details in FAQ responses to

address anticipated concerns, implementation requirements, objections or considerations relevant to end users.

Document reviews start as silent meetings, so stakeholders can read and reflect to form their own take before engaging in interactive discussion. This leads to more thoughtful exchanges than those that rely heavily on pitch presentations in PowerPoint.

In practice, the advance work is intentionally rigorous, known to point proposers back to the drawing board to refine assumptions and provide proof of value supporting the outcomes described.

For example, the team developing the Kindle cited customer-centric outcomes before the first device was made; how its instant book delivery, reference capabilities, customizable display and long battery life transformed the experience of reading with improved accessibility, convenience and portability, which essentially became the script for its success.

Working backwards is an activation of Amazon 'Customer Obsession' and 'Think Big' principles that has been shown to manifest imagined outcomes with such clarity of purpose that it consistently yields substantive market value.

How Amazon works backwards

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Done correctly, the working backwards process is a huge amount of work, but it saves you even more time later. The process is not designed to be easy; it's designed to save huge amounts of time on the back end by ensuring we're building the right thing.

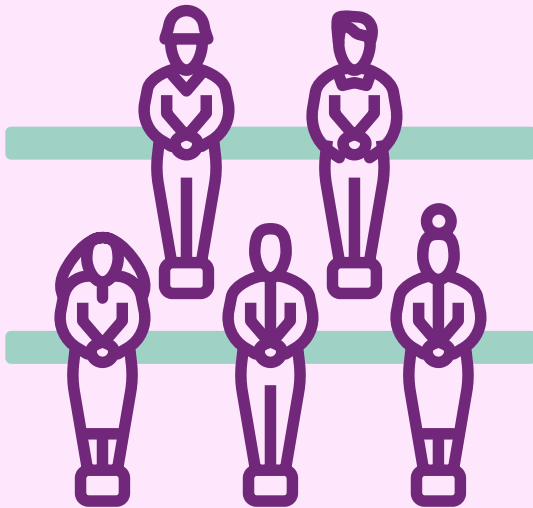
So many companies build the software [or product] and get it all working, then they throw it over the wall to the marketing department and say here's what we've built, write me a press release for it. That process to me is backwards.

— Jeff Bezos,
The Founder of Amazon



Two

An integrated 'one team' approach



In a truly collaborative, integrated delivery team, when you walk into the project office, it's not clear who is employed by the client/owner, consultant, contractor, or supply chain partner. Which is the point.

Everyone is part of one, unified team working together with common focus on delivering program outcomes, all bringing a breadth of expertise for every stage of execution, from initiation, to delivery and operation.

As the illustrative story goes, during a tour of NASA's Kennedy Space Center, President John F Kennedy saw a janitor carrying a broom. The President walked over to him, introduced himself, and asked the janitor what he was doing. The janitor replied: "I'm helping to put a man on the moon, Mr President."

Good governance and organizational design, defined early and agreed by the client, consultants and contractors, is essential to set up the project and team on solid footing for collaborative delivery. Taking a systematic approach to fitting together all parts of a delivery team, assigning clear roles and responsibilities and aligning all parties to the shared vision lays the foundation to optimize effectiveness from the outset. Beyond this, it aids the creation of a work environment that people want to be part of and give their best in pursuit of the program outcomes.

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Every type of supply chain you can imagine was involved in Expo 2020 Dubai – probably the entire country in some way. Whether consultants, contractors, those supplying materials, supplying plants, supplying food, supplying drinks – everybody was involved.

We had to spend a huge amount of energy and effort building the right culture, building the right behaviors. Those were absolutely critical for delivery. You also have to work with your contractors as partners and make them feel good about working on the project.

We tried as much as possible to engage with the supply chain and contractors as early as possible when we were doing the master plan so they understood what Expo was, its importance and the scale of the opportunity.

—Ahmed Al Khatib, Chief Development and Delivery Officer, Expo 2020 and Expo City Dubai, UAE



Building a highly-capable, integrated team

In May 2020, amid the escalating global COVID-19 pandemic, the UK government created the Vaccine Taskforce (VTF) to expedite the development, manufacture, and deployment of effective vaccines – a megaproject by any definition.

Tasked with a project of unprecedented urgency and complexity, the UK government appointed Dame Kate Bingham, a biotech venture capitalist with no formal civil service or public sector background, yet experienced in building teams and launching new products, to lead the effort.

Core to delivering any nationally significant project is building a high-performing and highly capable team aligned to delivering your key outcome and objectives. That's exactly where Dame Kate began. Her primary focus was assembling a high-performing team with the skills, agility, and mindset necessary to navigate the scientific and logistical challenges ahead.

In contrast to the approach of many megaprojects, the VTF didn't focus on the number of people in the team it was building or on how many were 'internal' hires (i.e. from within the civil service) or from outside. The key priority was finding the right people for the right roles and establishing a team of true world-class experts that could be trusted and empowered to deliver.

Dame Kate recruited leaders from across industry and academia, including Ian McCubbin, formerly of GSK, to oversee manufacturing; Divya Chadha Manek from the National Institute for Health Protection to lead clinical trials; and Ruth Todd from the Ministry of Defence to manage operations. Each was

given autonomy over their area, fostering accountability and rapid decision-making. The result was a dynamic, interdisciplinary team with a laser focus on the key outcome (securing early access to vaccines for the UK) and a strong sense of ownership.

The diversity of the taskforce was key to its success. By drawing on professionals from different sectors, with a range of technical skills and experiences, the VTF team could tackle complex problems from different perspectives with credibility and creativity. This richness of perspective, combined with trust and empowerment, enabled the Taskforce to move at speed without compromising rigor.

Under Bingham's leadership, the VTF helped the UK to secure multiple vaccines before most of the rest of the world and to begin its mass immunization ahead of any other country, with Margaret Keenan receiving the vaccine on the 8th of December, 2020 – only six months after the Taskforce was created.

Ultimately, the Taskforce played a central role in securing more than 350 million doses across various platforms, mitigating the risk of scientific failure to achieve stunning success accelerating the development and delivery of life-saving vaccines.

The UK's COVID-19 Vaccine Taskforce

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By March 2020 a small internal COVID-19 vaccine team was coming together... but the tiny band of officials [civil servants] had little expertise in the pharmaceutical industry or knowledge of recent advances in vaccine development. On their own, they were unlikely to slay the COVID-19 Leviathan. They would need skills that lay beyond the confines of Whitehall.

The team [we built] was highly effective, I think precisely because of empowerment and [a] very clear mandate, and also because of the team's diversity—not only gender, age, and ethnicity, but also diversity of thinking.

— Dame Kate Bingham,
Chair of the UK's COVID-19
Vaccine Taskforce

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Three

Shared risk and reward framework aligned to outcomes



As we have highlighted, all organizations involved in delivery, development or operations – from top to bottom – need to be aligned to key performance objectives to achieve the outcomes envisioned.

This can be aided through collaborative contracting and incentivized performance measures promoting shared risk as well as reward to overcome traditional conflict challenges and associated delays.

The implementation of shared objectives, key performance indicators (KPIs) and commitments – fosters a sense of ‘we’re in this together’ when backed up by meaningful rewards for successfully meeting targets. This can be especially powerful when applied across the supply chain, as it demonstrates to suppliers that they’re an important part of the project team by enabling them to earn

rewards for excellent performance. Incentivization is key to managing under-performance in a balanced way, by clearly outlining reward opportunities for meeting KPIs and the consequence of reduced earning potential for failing to meet them. Aligning both upside and downside performance incentives strengthens accountability and procurement by encouraging all of the parties involved to put their best foot forward.

The incentive framework for the London 2012 Olympics program provides a useful example of fairly allocated risk and reward that drove outstanding performance.

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Show me the incentive and I will show you the behavior.

— Charlie Munger
Co-Founder of Berkshire Hathaway



Sharing risk and reward to deliver on outcomes

Although now more than 13 years old, the 2012 London Olympic and Paralympic Games continue to yield generational value to London and the UK today.

It remains the gold standard of megaproject delivery, exemplifying how large-scale capital programs can and should be delivered, not only because it was completed nearly a year ahead of schedule and 10% below budget, but also because of the outcomes enabled by effective execution.

The Olympic Delivery Authority (ODA) engaged a joint venture of Mace, CH2M Hill and Laing O'Rourke, known as 'CLM', as the delivery partner responsible for managing the £8.9 billion mega program of publicly funded capital projects.

Given its public profile and scrutiny, the ODA aligned CLM's interests to ensure on-time, on-budget delivery with an innovative contract structure

that put a significant portion of CLM's profit at risk, tied to performance measures required to deliver the plans and obligations promised.

The ODA used an NEC3 contract with CLM that was essentially cost-reimbursable with strong risk/reward and incentive-based elements. This meant that in practice, CLM shared delivery risk and received incentive payments only after achieving the milestones, KPIs and cost benchmarks agreed. It tied CLM's income directly to outcomes – such that if key targets were missed, CLM fees related to those objectives would be reduced accordingly by proportionate measure.

The approach was designed to drive continuous improvement and delivery at pace, including risk/reward mechanisms to promote alignment and collaboration across the supply chain. Instead of a one-time payout at project completion, incentives were sequenced in incremental intervals within project stages. By aligning payments in intermittent phases from preliminary tasks through design, construction and operation, the contract helped to incentivize continual progress and collaborative problem solving to avoid misses or last-minute scrambles to meet requirements. Such mechanisms included:

Pain/gain cost sharing: a pain/gain provision aligned CLM's compensation with cost outcomes, meaning if the program came in under the targeted budget, CLM would receive a share of the savings as a bonus (capped at £50m); if over budget, a portion of their profit was at risk. This gave CLM a strong incentive to drive cost efficiencies on behalf of the ODA to deliver all program

requirements on-budget and on-time.

Milestone & KPI-linked fees:

CLM's fee was tied to key performance indicators (KPIs) for time and cost, with incentive payments released only when defined project milestones and KPIs were achieved.

Scheduled bonuses: the ODA also built in rewards for outperforming critical deadlines. Delivering work ahead of schedule earned bonus payments, reinforcing the importance of the fixed timeline dictated by the Games. Conversely, any delay would reduce CLM's earnings.

This approach effectively aligned the delivery partner and ODA incentives to meet key outcomes of the program. CLM had financial and reputational stakes invested in delivering to plan, and in turn, took an integrated, 'one-team' approach to align contractors and suppliers with the ODA as well. As a result, the London 2012 program was delivered in exemplary fashion, ahead of schedule and within budget.

London 2012 Olympic and Paralympic Games

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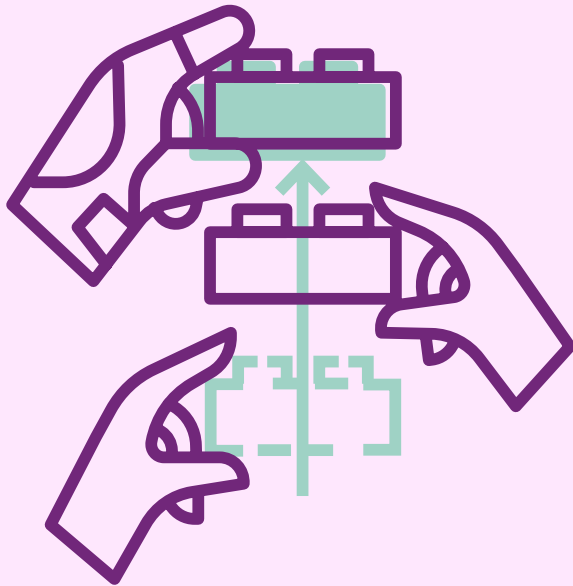
The Olympics was first and foremost a huge exercise in program and project delivery. Delivery is often a challenge for the government... but the Olympics were delivered on time and to specification. This was because of the combination of time invested upfront in getting the scope right and tight control on scope changes. A substantial proportion of the ODA budget was spent on program management, using a highly incentivised delivery partner, CLM. The NEC3 contracts used for the venues incentivized contractors to act collaboratively. Delivery was left to those best placed to do it.

— Sir John Armitt,
Former Chairman
of the Olympic Delivery
Authority

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Four

Highly collaborative in every sense



The essence of any successful project, organization or business is about assembling and uniting a capable team to serve the best interests of the project by working together as one cohesive unit.

A highly collaborative organization needs clear and transparent communication, well-defined roles and responsibilities, shared tools and systems, alignment to outcomes and objectives, trust and mutual respect.

Collaborative program management partners can bring these behaviors and also advise owners on organizational design and development, underpinned by maturity and cultural assessments to help them build the right tools, capabilities, structure and team culture for successful execution.

This level of collaboration needs to carry through to

physical delivery as well, and it is also important that clients and consultants support contractors to ensure this.

To enable clients to achieve this, a collaborative approach that also affords active oversight of construction works is needed. This can be enabled through a Project or Construction Management Office that activates controls and shares information with all parties, and provides insights, reporting and recommendations to project functions to enable real-time, best-for-program decisions. This management role is usually developed and assured by the consultant partner to drive effective delivery.



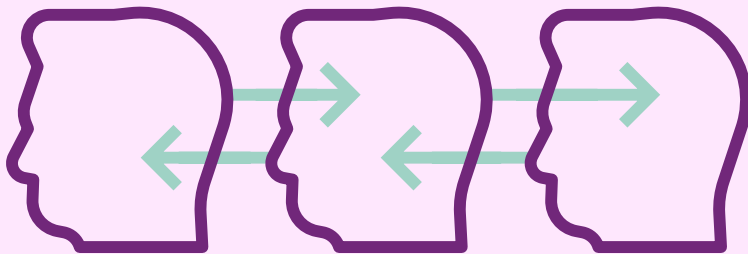
Collaboration doesn't mean always being 'nice' to each other, but working to align the interests and objectives of different individuals and organizations through frank negotiation and candid communication. Honest conversations can come with tension, but having the right values and behaviors in place helps teams to navigate this. The outcome is clarity, with everyone knowing the role they have to play and the benefit it will bring.

— Caroline Lassen,
Director for Program and Project
Management, Mace Global Consult



Five

Knowledge transfer and capability building



As many client organizations have limited experience delivering projects of mega- or giga-scale, some form ‘special purpose’ entities to plan, deliver and even operate new infrastructure programs.

Since large programs and projects often last for a decade or more, they are likely to experience turnover on the delivery team. As managers come and go, knowledge transfer, capability development and succession planning play a particularly important role in sustaining progress.

A key feature of the delivery partner approach involves formalized knowledge transfer and development as part and parcel of the outcomes to be delivered, allowing client organizations to benefit from best-practice learning, institutional knowledge and

practical experience throughout the life of the program.

The long-term nature of the partnership also allows for the upskilling and development of other team members and supply chain partners, all of whom gain valuable skills and experience, as well as opportunities to support the delivery of future programs while growing capabilities to enabling them to progress to more significant roles over time.

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There are very few people within the public sector who have experience of delivering on megaprojects. Projects of this scale require a different skill set and many clients haven’t got enough capability.

— Director,
Highways Infrastructure, UK

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Six

Long-term relationships

Psychologically, people act quite differently with those they know they will be working with over years compared to those they are only seeing for a few days or weeks.

Similarly, if businesses invest in greater continuity and stability of relationships, people will invest into and act to support long-term outcomes rather than focusing only on immediate circumstances^{xxiii,xxiv}.

For example, when an organization brings in different design, engineering and consultant teams at different phases to contribute to project plans, time and cost estimates, it sets the stage for disjointed management, information gaps and conflicts between the various parties involved.

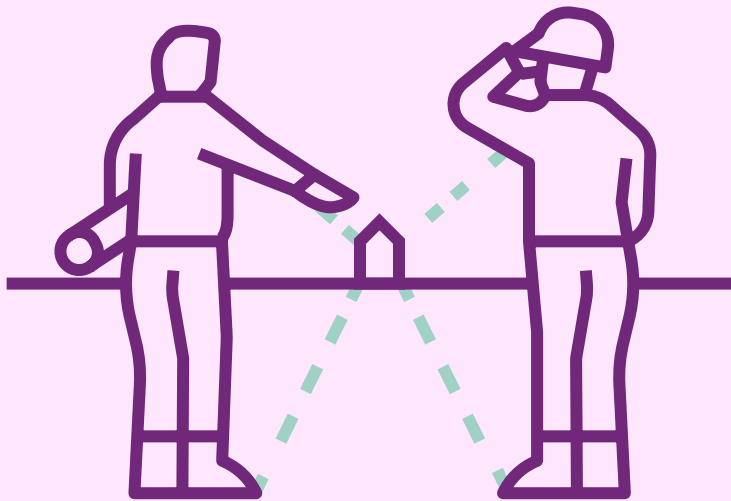
Long-term relationships, inclusive of project partners, provide a common frame of reference and greater

continuity. Fostering such relationships over time helps to eliminate ambiguity and information silos, enabling parties to work together from the 'same page' to deliver the program.

In contrast, a disjointed approach tends to promote fragmented execution, and in a practical sense, makes it impossible for parties to understand or act in the best long-term interests of the project when they don't have the complete picture or a common frame of reference

A noteworthy pitfall of disjointed management and a lack of long-term relationships is failure to appropriately consider constructability.

Moreover, the gap between planning and construction phases is a recipe for failure when one team is incentivized to create a series of outputs that may seem right early in the program, and others, with no connection to the early considerations, are expected to execute them while compensating for changing realities down the line.



Seven

Look beyond leadership for key decisions



All major parties involved in the project—the client, delivery partner, contractor and subcontractors—need to be involved in major decisions together.

The shared risk-reward framework means that all main parties involved have the ability to influence project performance and outcomes. Including them in decisions promotes collaboration and a shared sense of ownership for successful delivery. It allows greater opportunity for innovation and improved delivery by reducing the potential for misunderstandings, conflicts and claims.

Eight

High capability consultant team with a breadth of involvement



A collaborative approach does not prescribe a fixed number of staff for the duration of a project. Rather, it is meant to thoughtfully deploy the right people and resources at the right time to perform work precisely as required.

For maximum effectiveness, the consultant partner manages execution across the breadth of roles and functions required for optimal performance. This provides the visibility needed to aptly manage interface challenges while also maintaining 'skin in the game' that helps maintain focus on critical delivery requirements.

Where clients show a willingness to embrace fully integrated execution, it is likely they'll have a better chance of positioning themselves as an '*employer of choice*', boosting their status in the industry and, therefore, taking steps to combat constraints in workforce availability.

Nine

Trust and transparency



Trust is the most essential ingredient in enabling teams to work collaboratively toward a shared goal. If parties do not trust each other, a significant amount of energy is wasted dealing with friction, diverting precious time and resources away from delivering on project requirements and outcomes.

Misunderstandings, mis-information and not having the full picture can all create distrust, which is why it is so important to provide maximum transparency, with project information and communication shared openly across platforms and systems accessible to all participants. This is an important function of a PMO – to provide transparent tracking, communication and guidance to build trusting relationships and aligned performance. People will only do what's best for the program when trust and transparency are in place.

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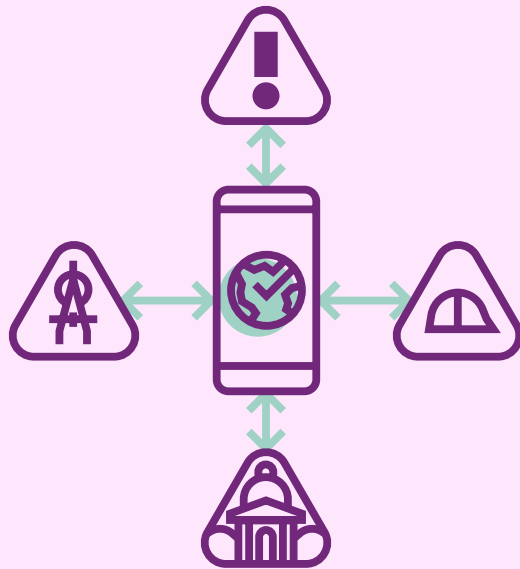
Things always come back to trust. To build trust you need transparency so people don't spend too much energy second guessing.

— Senior Executive
Life Sciences and Pharmaceuticals Company



Ten

Integrated technology and processes



Not having a common, singular version of ‘the truth’ can cause significant lapses in performance required to progress through project phases, which can be especially problematic when moving to operation.

It also impedes collaboration and transparency – that’s why Mace’s delivery partner approach draws on the POPIT management model to align People, Organization, Process, Information, and Technology. This enables consistency from start to finish. A shared version of the truth should be focused on the essentials—performance measures and forward-looking indicators that drive execution.

From the site level across the portfolio of assets, integration of processes technologies with clear information, structured configuration and collaboration among all parties and supply chain partners are core ingredients to enable effective, successful delivery.

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Nowadays, project data is openly available and everyone wants a dashboard. So many are being created that people don’t really understand what they’re looking at, or what the key issues and messages are. We need to streamline this approach so it’s easy to focus on the critical issues that need to be addressed.

— Executive Director,
Major Programs, Middle East

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Bringing it all together

Metrolinx, an Ontario agency responsible for managing and improving Greater Toronto's transport system, has embarked on one of the biggest transit infrastructure programs in history: the GO Expansion and Subways extensions.

Metrolinx, the public transportation agency for the Greater Toronto and Hamilton Area mega region in Ontario, Canada, has embarked on the largest transit infrastructure program in the nation's history, expanding the GO surface rail system and extending subway lines to increase connectivity and service in North America's fastest growing metropolitan area, with current population estimates topping 10 million.

Due to the scale, complexity and transformational nature of the programs and numerous projects entailed, leaders recognized that a collaborative approach with an experienced delivery partner would aid successful delivery, integration and operation of new and existing system components.

Metrolinx selected a joint venture of Mace, Comtech and SYSTRA (MCS) to act as delivery partner for the GO Expansion, working as an integrated team at enterprise, program, and project levels to manage complex workstreams involving varied contract types and multiple delivery methods.

At the enterprise level, the partnership's role is twofold: providing construction oversight tying together various active projects, while also building local delivery capabilities for future program. From the outset, Metrolinx and MCS jointly established program governance, an integrated team, and delivery plans designed to pre-empt problems and maximize value.

At its core, the \$61 billion,

10-year GO Expansion program is turning what has primarily been a system providing commuter services into an all-day, high-frequency transit network with trains running every 15 minutes. The improvements will transform the region's entire mass transit network, making it a highly efficient system that, once fully operational, will have the capacity to serve more than 200 million passenger trips per year.

The highly complex program is progressing as planned, with more than 375 miles of electrified track, 78 miles of new track, 40 new stations, signaling systems, supporting infra-structure and maintenance facilities.

Building on trust established in the GO program, Metrolinx and MCS subsequently launched a second delivery partnership to oversee projects extending the Scarborough and Yonge North subway lines, comprising \$11 billion in capital investments. The Scarborough project marks Canada's first use of the progressive design-build model with an adjacent design-build-finance contract to construct a new 4.8-mile, two-way tunnel. It also includes four new stations, traction power, signaling, and ventilation systems.

MCS and Metrolinx are applying lessons learned to support the Yonge North subway extension, which includes a 5-mile, twin bore tunnel and five new stations. And, as with GO, Metrolinx and MCS formed an integrated team to collaborate on the Subways program, including the progressive-design builder, the operator, tunnel representatives, and local municipalities to enable effective delivery. Given the complexity of the organization and number of new contracting mechanisms involved, capabilities development is a core part of the program to help Metrolinx successfully implement the progressive design-build model, while maintaining the schedule and target-cost negotiated-price provisions for the program.

Throughout delivery of all of the projects, the partnership leverages industry-best practices, collaborative management and continuous improvement, while building local supply-chain and workforce capabilities enabling industry-leading performance, delivery assurance, and outcomes benefiting the wider community.

Metrolinx's GO Expansion in Toronto

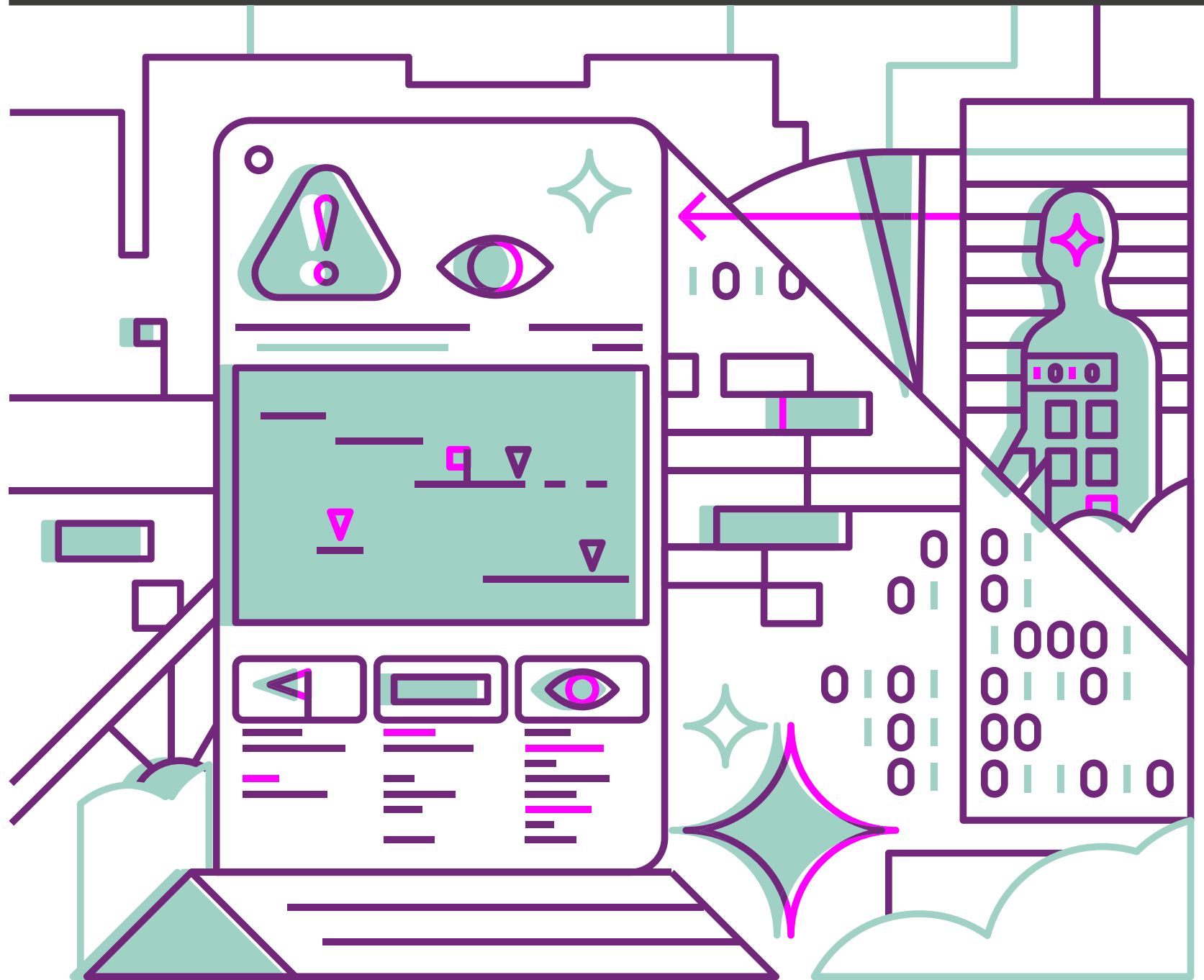


The essence of delivering a successful large project is having clarity on what you want to deliver and why, the right team that trusts each other, a fully resourced schedule, consistent processes, systems and a common data environment. You need to have one version of the truth and the right information to make decisions.

— Warren Kencroft, Vice President, Technical Integration, GO Expansion



The role of digitization, data and AI in delivery



The role of digitization, data and AI in delivery

Given this report looks at the future of major program delivery, it would be remiss of us not to dedicate time to look at the trending topic of data, digitization and AI.

Since ChatGPT was launched in December 2022 there has been a clamor of excitement to integrate AI into different industries for different purposes.

The broad application of AI and innovative data tools on mega and giga-projects has the potential to help break the ongoing cycle of over-budget, late projects and with disappointing realization of benefits and outcomes.

Understanding the huge consequences of inefficiencies in megaproject delivery, our estimates suggest the global economy is at risk of missing out on more than \$1.5 trillion of growth by 2030,^{xxv} – value that could be recovered for the greater benefit of society, reflecting a conservative 1:1 cost-benefit ratio applied to assess the value of lost economic benefits globally.

As we've noted, major projects and programs are most likely to succeed when there is clarity of direction, trust, the right incentives, accountability, and timely decision-making. AI can be seen as an enabler of these principles; a tool capable of processing extensive data to

provide comprehensive information and considerations, helping program leaders make more informed choices aligned with desired outcomes.

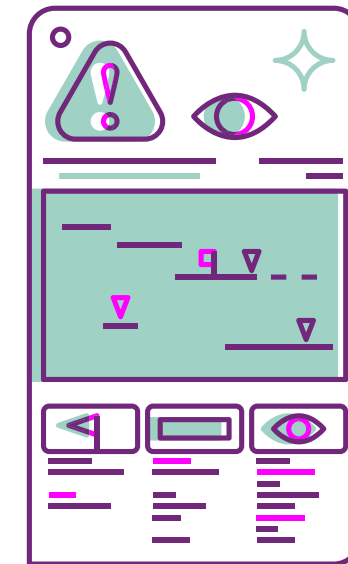
For instance, an AI-driven dashboard might highlight that a key milestone is likely to slip or that a risk indicator is trending upwards, prompting earlier intervention than what normally might happen to prevent intensification. But it still takes an integrated team to consider the full picture and best way to address the concern.

Used pragmatically, AI can help to overcome optimism bias by enabling predictive analytics based on a wide body of reference class data to ground wishful thinking with a healthy dose of reality, and ultimately, improve forecasting. So, from the start of planning, AI can mine historical data reflecting similar projects and circumstances to produce more realistic projections and flag risks hidden in patterns that humans might fail to see, thus informing the 'outside view', in the words of Daniel Kahneman).

Designers can also leverage AI simulations to test scenarios and options^{xxvi}. A digital twin

of proposed infrastructure, such as a bridge or rail corridor, serves as a parallel 'reality portal' that lets decision-makers experience and explore different options and outcomes tied to project variables, revealing potential clashes or operational considerations before owners commit significant work and resources that are difficult to change or undo down the line.

Our interview with Ahmed Al Khatib of Expo 2020 in Dubai noted how AI used for 'clash detection' saves time and money in the long run:



“We built a digital city in a BIM model which put all the designs in one place. We detected so many clashes using AI – I’m talking hundreds of thousands. Imagine if we discovered those during construction – the significant cost, disruption and redesign.”

By properly stress-testing plans up front with more extensive, AI-powered predictive analytics running ‘what if’ scenarios, program leaders can gain valuable insights enabling them to pre-empt issues and risks that otherwise might not emerge until after construction is under way.

AI also can help to resolve a perennial challenge that occurs when fragmented procurement and supply chains create information silos and gaps between various parties that often result in inconsistencies, disconnects, delays, wasteful rework and misunderstandings. AI can be applied to identify interdependencies so leaders can close gaps that might otherwise cause missed hand-offs and delays.

While a collaborative delivery model can help with such challenges, AI and other digital tools serve as a valuable complement, such as using intelligent procurement platforms to forecast material demand and automate orders, while providing real-time logistics tracking so that materials and equipment arrive exactly when needed.

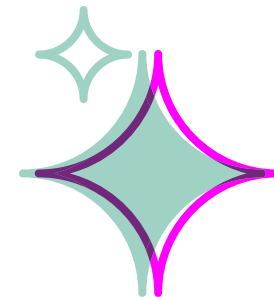
Likewise, AI systems can be used to integrate scheduling with live data on weather, team availability and site conditions, optimizing work plans to keep projects on track. The result is not just efficiency but also transparency. Stakeholders get a live, data-rich picture of progress rather than intermittent reports. And, by streamlining these processes, AI can bolster collaboration and streamline delivery by reducing costs and delays across the project ecosystem.

Of course, the application of AI still presents some challenges for the construction industry. In fact, over the last 20 years, productivity levels in construction have remained stagnant – in part because it's one of the least digitized industries, traditionally investing less than 1% of revenues on technology and development.

Yet there is growing recognition in the industry that we cannot go on delivering projects without taking full advantage of digital and AI capabilities to address long-standing problems – from poor cost estimating to lacking productivity, to inefficient logistics for optimal delivery and operation of capital projects and assets. Indeed, industrial companies and government leaders in Hong Kong and the Middle East seem to be ahead of the pack when it comes to actively applying digital and AI in megaproject delivery.

While AI won't replace project managers or engineers, it can augment their capabilities and reduce biases, while taking over tedious tasks and processing large amounts of data. These applications enable project professionals to make more informed, thoroughly considered decisions.

The productivity benefits that can be achieved through digitization and the application of data and AI have an important part to play in closing the infrastructure gap. But wider adoption is needed for value to be fully realized, which requires a shift in mindset and work methods. Too often, it seems that AI is perceived as a threat to jobs, when that's not really the case. Professional acumen and people skills remain invaluable as the currency of effective delivery, with AI providing a helpful boost to productivity and efficiency.



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AI and big data are possibly the most important parts of projects nowadays. If you're not using them, you're missing perhaps one of the most critical elements in project delivery.

— Senior Executive,
Life Sciences and Pharmaceuticals Company



An AI early-warning system for megaprojects

Forecasts suggest that construction expenditures in Hong Kong will rise to \$39 billion annually in the coming years; a 30% increase since 2021.

Hong Kong is in an unusual position globally, with projects typically coming in 15% below budget. Moreover, only 10% of megaprojects in Hong Kong overrun their budgets, versus the 90% rate of cost overruns for large-scale projects globally, while among those that exceed budgets in Hong Kong, the average margin of overspend is just 8%; very effective by international standards.

To prepare for increasing investments and pave the way for effective delivery, the Development Bureau of the Government of Hong Kong SAR (DEVB) has moved to digitize its \$77 billion portfolio of public works assets across the design, construction and maintenance lifecycle.

Given Hong Kong's governance structure, the DEVB acts as the singular policy bureau overseeing all public works across various departments, a degree of centralization not commonly found elsewhere in the world, enabling an industry-leading digital management model.

The DEVB implemented an integrated ecosystem including a Digital Project Delivery System (DPDS), a Digital Works Supervision System (DWSS), and a Project Surveillance System (PSS). These systems centralize data from more than 200 active public works projects (involving 300+ contracts and 700 consultancies) into the self-developed Integrated Capital Works Platform (iCWP). This enables AI and predictive

capabilities that are revolutionizing project and portfolio management in Hong Kong.

The DEVB developed the PSS in 2018 as part of Hong Kong's Construction 2.0 agenda and aims to improve project governance, predict risks, and facilitate early interventions. The web-based tool continuously monitors and analyzes cash flows of ongoing projects. Projects submit actual and forecast cash flow data, which are assessed against patterns derived from a historical database of relevant projects. Each project is rated using a traffic light system: 'green' for normal progress, 'amber' for potential issues needing departmental review, and 'red' for critical concerns requiring

top-level, priority attention.

The system was further enhanced with an AI-enabled early warning function in 2022. The AI model was trained on data from 849 completed projects valued at HKD 460 billion (\$59 billion). A custom-developed algorithm, described as a 'rolling discretizer,' proved most effective in identifying characteristics of high-risk projects. The AI achieved up to 70% accuracy detecting projects with potential cost overruns and schedule delays.

Even more intriguing is the finding that the AI required only about 10% of a project's data to generate meaningful predictions. This suggests the PSS can be applied early in a project's lifecycle and could become an intelligent benchmarking technology with the capacity to continue to improve over time.

Hong Kong's Project Surveillance System

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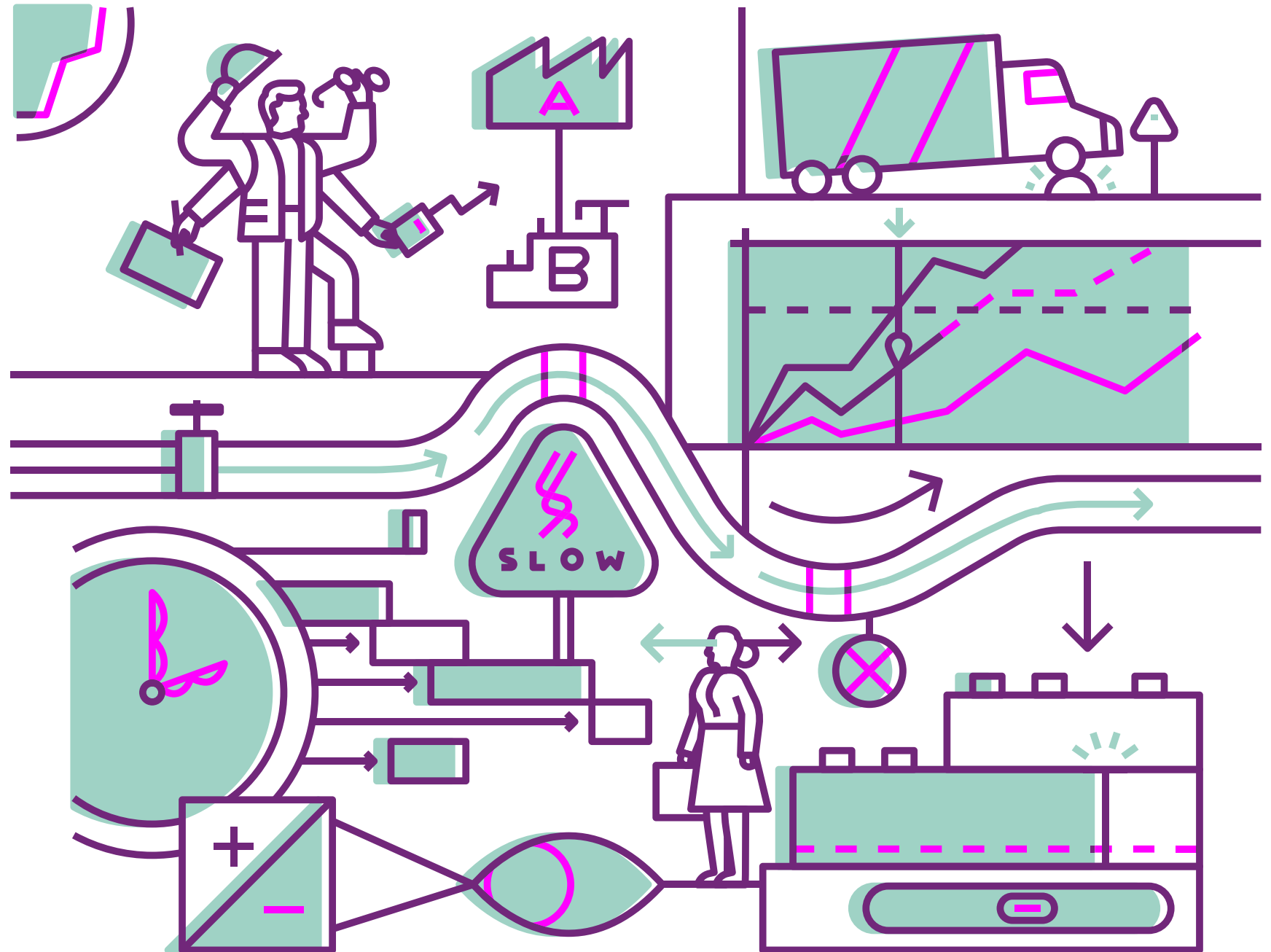
By referencing data on project cash flow, we can forecast whether the project is tracking to be under or over budget, and whether it may suffer delays. Assisted by AI, we're able to make these predictions earlier on in the project lifecycle, giving us a better opportunity to put solutions in place and reduce risk.

— Joseph Lo, Head of Project Strategy and Governance Office, Development Bureau of the Government of Hong Kong SAR



Actionable solutions

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Actionable solutions

Now that we have a good understanding of the state of mega and giga-scale project delivery, common challenges, and collaborative frameworks to solve them, we offer a set of 12 actionable steps that can make an immediate, positive difference for large programs being delivered today.

1 Start with the purpose

4 Establish clear and stable pipelines

7 Do the basics brilliantly

10 Change scope with care

2 Be a well-governed client of choice

5 Enable purposeful procurement

8 Ensure cost realism

11 Hold a 'pre-mortem'

3 Slow down to go faster

6 Value time

9 Draw on global experience

12 Think off-site

1. Start with the purpose

Nearly every one of our interviewees touched on the importance of understanding why a project or program is being undertaken, the problem or issues it's meant to solve, and the key outcomes that need to be achieved.

Success on a mega- or giga-project scale stems from having absolute clarity about the 'why' and the outcomes required. It's also important to validate causality as to how it will bring about key outcomes and how they should be prioritized—those which are 'essential' and those which are 'nice to have'. This sets projects up to

succeed as the right solution and helps to shape informed choices around scope, cost, timing and how they can best serve the purpose defined.

What's more, establishing a clarity of purpose early helps to build relationships and buy-in with the greater community, as noted by Mohamed Saad, President, Diriyah Company:

"When a project has a clear purpose and the surrounding community is properly engaged on it, you can create a sense of pride. People feel like they are part of something bigger and, when combined with

tangible benefits that will improve their quality of life, you generate valuable local support for your plans."

2. Be a well-governed client of choice

Our interviews consistently highlighted that for projects to succeed, they need to have a client or sponsor organization that's as high-performing as the delivery organization.

Such clients understand their strengths and how they reflect the type of client they aim to be – whether that is a 'lean', relatively small team, or a

team that's flush with internal staffing capacity. Depending on the situation, there are good reasons for each type, but our interviews found that clients often do not give due consideration to that question, and as a result, aren't prepared to make intentional choices about their organizational design. This is important to define the delivery model and organizational development needed to successfully deliver a program of scale.

Our analysis shows that the average megaproject delivery lasts for a decade. Clearly, the team that initiates the project is

likely to have turnover to the extent that it may change significantly by the time it reaches completion. So, from the start, well-prepared clients have robust succession and development plans in place to provide continuity and ready the next generation of leaders to see the project through to a successful finish.

Well-positioned clients also recognize their organization's strengths, weaknesses, opportunities and threats, and partner with organizations that bring the complement of capabilities they need to succeed. This understanding can be achieved with a 'maturity assessment' such as the P3M3 diagnostic tool to chart a course to project management readiness.

Most importantly, our research found that the most successful clients make a significant effort to carefully consider prospective partners, ensuring that the resulting team combination has firm foundations of a collaborative culture, clarity of purpose and mutual incentive structures in place to drive the best possible performance and outcomes.

3. Slow down to go faster

Nearly all of our interviewees cited how the desire for speed can lead to hasty, misguided decisions in the earliest stages of the program, which ultimately costs more time and money in the long run.

A particular issue raised was not doing enough substantive work early on design, management protocols, logistics, constructability and deliverability before actually starting work on site and fully engaging contractors. This is especially acute in projects where political pressures prioritize a visible, public show of tangible progress over less visible preparatory work that plays a far greater role to set the stage for a project's success.

To some it may sound counter-intuitive, but megaprojects especially need to slow down to reach effective completion faster. They need to resist the rush to start on-site until serious, detailed work has been done to define the why of the project, and more specifically, how it will resolve the need, what must be delivered, and how; delivery model, contract mechanisms, packaging and partnering.

4. Establish clear and stable pipelines

With global net profit margins within the construction industry ranging between 2-5%^{xxvii}, the sector is particularly vulnerable to the stopping, starting and scope shifts that affect projects of scale. Scant profitability and industry fragmentation conspire to constrain cash flows, making it difficult for many construction firms to expend significant resources for business and staff development when they also struggle to keep people employed amid project stalls or demand downturns.

This becomes a liability for project owners and sponsors as well, warranting consideration of mitigation measures to smooth out the typical extremes of demand volatility in construction. Such measures could include creating longer-term capital investment strategies, multi-year funding settlements, the use of arms-length entities to enable flexibility in funding decisions, and economic development measures aligning public-private support, cooperation and incentives for priority projects. Publicly funded pipelines also need to be open,

transparent and realistic. In several countries we studied, significant pipelines were published with a sizable quantity failing to ever materialize, causing the construction industry to lose faith in the data.

5. Enable purposeful procurement

“One of the things that can lead to a suboptimal outcome is when we procure everything in exactly the same way, which some large organizations advocate. Clearly there have to be guide rails, but my preference is to look at the specific need and then work out who the best supplier is from a technical and relationship perspective. Make sure you have a baseline cost and schedule you're working to, then do the deal that motivates them for their style of working.”

—Ruth Todd, Operations and Supply Chain Director, Rolls-Royce SMR

Procurement also can make or break project and program delivery, as it hinges on getting the right people, partners and suppliers on board and working as part of a unified team.

The complexity, effectiveness and approach to procurement varies greatly around the world, with a common challenge being that organizations and commercial teams can lose sight of the program's purpose and end up placing greater emphasis on procurement protocols than purpose-driven priorities.

For example, while there has been a move in the right direction with greater uptake of best practices like in NEC contracts, procurements in Latin America still focus primarily on price rather than technical capability and experience considerations. And on the other end of the spectrum, procurements in the UK are often so complicated by bureaucracy that they can take over a year to complete, and they still frequently meet challenges in the courts.

The central question of effective procurement is much simpler: does the bidding organization

have the right people, culture, experience, focus and capabilities to deliver the project or program effectively?

To answer that question, the procuring organization must look beyond the standard processes and paperwork to prioritize meaningful, face-to-face engagement with prospective providers. Whether this includes behavioral assessment, presentation and discussion with an interview panel, or an ongoing period of dialogue and discussions before and during the tender itself, such qualitative engagement is especially critical for mega-scale procurements to get to know prospective providers to assess their capacity and cultural fit with the project organization and key partners. This is crucial to build a high performance team.

Megaproject organizations especially need to afford adequate in-person time with bidders, remembering that the procurement's ultimate aim is to identify the very best long-term partner to deliver the full promise and potential reflected by their program's purpose.

6. Value time

Time is as important as money when it comes to delivering mega and giga programs, not only because of their durations but also given aims to leave a legacy beyond the works, generating ongoing socioeconomic benefits.

In some Western countries, there has been a view that the industry has become conditioned to accept that megaproject procedures and decisions will take excessive time while producing few benefits to show for it. For example, running design sign-offs through a gauntlet of multiple levels of reviews with different departments and organizations, some of which lack expertise or context to provide input or feedback of significant value. The proliferation of bureaucracy and ever-larger project teams is propelled by the idea that ‘throwing more people’ at the project will lead to better outcomes. Yet our research found that more often, the opposite is true.

The longer a project goes on, the more likely it is to encounter significant external shocks— like present-day economic extremes,

policy swings, pandemics, disasters, security threats and geopolitical conflicts—the more likely they are to be affected by fallout effects such as delays, de-funding or costly changes.

All the more reason for mega-project leaders to adopt a time-value mindset to measure the work hours it takes to progress project decisions and task intervals in cost-benefit terms, thus ensuring the time spent contributes positive project value rather than a cost-benefit deficit.



7. Doing the basics brilliantly

This recommendation is not a new idea, but our interviews highlight persistent challenges when it comes to executing on the fundamentals required to optimize the delivery of large-scale projects and programs.

Our research points to clear scope definition as a core issue, involving basics like realistic, integrated delivery schedules that track inter-dependencies across multiple contracts, supply chain providers and work packages. Projects also need the right people in the right roles at the right time. And we cannot overstate the fundamental importance of clarity of purpose—the ‘why’ driving the project and causal factors that can make or break fulfillment of outcomes.

Other basics include: Excellent internal and external stakeholder communications to engage, inform and manage expectations. Consistent, transparent engagement is key to banish information silos and ambiguity among project participants. Vigilant risk management is a must to proactively track, identify and address potential problems. Common data and performance indicators must be widely shared, constantly updated in real time, and always visible, alongside measures for continuous improvement and formalized knowledge sharing about the project, further informed by reference to similar projects and relevant cases.

As simple as these basics may seem, our research shows that in practice on programs of scale, they remain persistent pitfalls that frequently deter delivery success.

8. Ensure cost realism

Many mega and giga-projects start from a point of failure because they rely on erroneous information or unrealistic assumptions, often driven by optimism bias, a desire to downplay costs, incomplete designs or misinterpretation of data. Any flaw in the multiplicity of elements that comprise a project’s baseline places it on shaky ground, with the potential to bring down the entire undertaking.

To place large-scale programs on sound footing, we suggest seeking qualified cost counsel applying rigorous reference-class forecasting to build realistic baseline parameters.

Thanks to AI, reference-class forecasting introduces objective, practical, project-specific discipline involving three steps:

1. Identify a ‘reference class’ of similar completed projects like yours.

2. Establish a probability distribution for the selected reference class for each of the parameters being forecast (e.g. time or cost).
3. Compare your project parameters with the reference class distribution to inform and establish an outlook reflecting the most likely outcomes.

The ‘top down’ application of real-world outcomes to estimate project costs and risks has been shown by various academic studies^{xxviii} to be more accurate and, if used in conjunction with traditional economic and cost modeling, could substantially reduce budget and schedule overages, by half if not better.

9. Draw on global experience

Given size, complexity and number of people involved, leading a megaproject is a highly specialized job requiring a broad range of skills akin to leading a large corporation.

The most successful megaproject leaders possess a breadth and depth of multi-disciplinary expertise informed by real-world experience.

They are adept at navigating widely diverging differences of culture, politics and opinion. They understand the nuances of organizational culture and how to cultivate best-practice sharing, learning and collaboration.

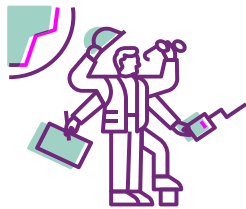
The currency of the most successful program leaders is an intangible *gravitas* that inspires the confidence of stakeholders in the course of change they are charged to lead; the ability to win hearts and minds that motivates people to follow not because they are told to, but because they want to. This turns a talented team into an elite, peak-performing team.

This is a mantle of leadership that relatively few construction industry professionals are fully prepared to assume.

To address this, we offer two suggestions: 1) Develop a global network of high-performing project leaders to share insights, support and challenge one another. 2) Add seasoned project leaders as non-executive directors on governing boards to lend experience and expert counsel to mega programs.

Moreover, to prepare the next generation of megaproject leaders, we advocate for specialized executive education as a collaboration involving industry associations, academic institutions and seasoned project leaders sharing practical experience from large-scale programs.

Finally, based on our own experience spanning three decades as a partner to successful mega programs around the world, we note that formalized knowledge transfer and leadership development should be included as a core requirement of every megaproject delivery.



10. Change scope with care

So many mega programs end up radically different – and radically more expensive – than their original concepts. Among the reasons: 1) unclear outcomes or clarity of purpose about the real need or issue the project is seeking to address; 2) a lack of value placed on time which allows projects to wander astray from their core purpose; and 3) continual 'scope creep' involving serial changes that together, add significant time and cost.

One of the main ways to combat scope creep is to use a delivery model that includes a fair pain/gain share for the delivery team while giving them a seat at the decision-making table. If all the parties share the upside of delivering on or under target cost, then they will be aligned in requiring a good rationale and evidence of value for any proposed change in scope.

Every major program should have a minimum viable product (MVP) that defines minimum requirements to deliver on the top-priority outcomes. This idea, which has been used in the tech industry to test assumptions, gain early feedback, iterate and prioritize focus for program success, is starting to gain traction in the construction industry.

Having an MVP doesn't mean cutting corners or compromising quality. Rather, it's meant to inform the development of a baseline that's very focused on achieving the most critical deliverables, objectives and outcomes fundamental to the program's ultimate success, such as the health, safety and wellbeing of those involved.

The MVP can then be used as a yardstick for decision-making to consider proposed variations affecting scope, enabling choices about additions or changes to be measured against clearly defined rationale to understand cost and schedule implications as well as other MVP outcomes.

11. Hold a 'pre-mortem'

With more than 11,000 mega-projects and 250 giga-programs currently in delivery – not to mention those completed in the last decade – we have a well-defined pool of experience and reference class of evidential data at our disposal.

Industry professionals are used to holding a project 'post-mortem' (or 'lessons learned') session at the end of each key project phase. But in our interviews, we found it's much less common to bring such insights forward to the start of the project lifecycle.

Those with a learning mindset will go out of their way to understand in painstaking detail what went well and what went wrong on other relevant projects of scale everywhere in the world, and subsequently consider how those real-world might apply to their own projects. This type of detailed 'pre-mortem' examination clearly offers valuable insights to benefit the management mindset and successful delivery prospects of the next new mega program.

12. Think off-site

Depending on where you are in the world, you might refer to offsite fabrication of construction components as 'Modern Methods of Construction' (MMC), 'Construction to Production' (C2P), 'Design for Manufacture and Assembly' (DfMA), 'Modular Integrated Construction' (MIC), or something else entirely. Whatever you call it, the premise is the same; a shift from traditional, labor-intensive on-site work to efficiently controlled, digitally enabled industrialized construction providing improved predictability, productivity, quality, and speed.

It's a particularly compelling solution for complex, multi-year programs under heightened pressures to move faster to operation, reduce the number of workers on restrictive sites, and minimize local emissions.

Components – from modular building frames to entire MEP systems – are made in a production setting and then built on-site with minimal disruption. The benefits of such an approach are many, from improved safety, quality and

throughput, to reduced waste, and dramatically shorten time on site. Ideally applied, it optimizes repeatability, interoperability, and scalability across products and sites which result in a continual learning process, economies of scale and a stable pipeline for the production factory.

Academic research has shown modular and prefabricated systems can triple productivity levels^{xix} while significantly increasing safety and quality. In Hong Kong, where their 'MiC' programs have been the subject of a good amount of academic research, they have been able to access cutting edge partners in Mainland China to provide high-levels of modularization. This approach led to 50% time reductions, 6-10% cost reductions and 100-400% increases in on-site labor productivity compared to traditional methods^{xxx}.

Mega and giga programs and projects need to think 'offsite-first' and look to create a design that optimizes for standardization for factory production and streamlined delivery.

Appendices

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Methodology and disclaimer

Acknowledgements

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Methodology and disclaimer

Bradshaw Advisory – on behalf of Mace – undertook analysis of more than 5,000 global megaprojects (capital value of \$1 billion or more) and giga-projects (\$10 billion or more) to assess how major programs are delivered across different markets. The analysis undertaken draws on tailored datasets provided by GlobalData, further enhanced by AI-supported analytics and targeted academic desk research.

GlobalData applied a series of filters to its global construction project database of more than 277,000 projects to generate a focused dataset of 5,330 capital projects. These filters included geographies with active capital pipelines and regional diversity: Kingdom of Saudi Arabia, UAE, Philippines, Hong Kong, India, Australia, UK, Ireland, USA, Canada, Peru and Colombia. Projects were then only included if their capital value exceeded \$1 billion and if they were at one of the following stages: Announced, Study, Planning, Pre-Design, Design, Pre-Tender, Tender, EPC Award, Execution, or Construction Complete. This is our Primary Dataset.

In addition to the Primary Dataset, the research team used a second, complementary dataset from GlobalData focusing on inactive and on-hold megaprojects across the same set of countries (Complementary Dataset). Together, these two datasets (our Foundational Dataset) provided a robust empirical foundation for understanding and analyzing how large-scale capital programs are conceived, funded and delivered, offering insights into both high-performing projects and those facing significant barriers to progress.

For comparisons where consistency across time and geography was essential, such as cross-country volume analysis, we limited the data to projects initiated since 2010, reflecting the period when GlobalData began systematic tracking. Both data sets were used individually and when combined. Earlier projects were excluded from these comparisons to ensure robustness. However, for other parts of the analysis where large sample sizes were preferable and time comparability was less critical, the broader dataset was used.

Techniques applied

Descriptive statistics were then applied to the Foundational Data set to enabling us to examine distributions of project volume, value and type across geographies, sectors and time periods. This supported a broad suite of analyses, including assessments of megaproject growth over time, comparisons of pipeline scale and benchmarking of delivery performance across countries.

Duration analysis was conducted using structured timeline fields such as Announcement and Construction End Dates to calculate project lifecycles. These metrics were then benchmarked across geographies and sectors to assess systemic differences in delivery timelines. A supplementary dataset containing stalled and inactive projects was used to support comparative analysis of pipeline activity across countries and sectors, while a natural language processing (NLP) model was deployed to identify schemes showing signs of severe disruption based on unstructured project update fields.

Where appropriate, secondary sources were used to supplement the data and validate key outputs, helping to contextualize results within broader industry trends.

Natural Language Processing (NLP)

To identify infrastructure projects at risk of severe delay, a Python-based NLP methodology was developed to systematically assess risk across a global portfolio. Using a custom-built phrase bank of disruption indicators and a pre-trained sentence transformer model based on BERT, the approach analyzed project updates to detect signs of severe disruption.

A highly conservative phrase bank was defined, deliberately excluding routine delays or early-stage uncertainty, which occur across a large portion of projects, in order to reduce false positives. The model compared sentences in each project update to the phrase bank using semantic similarity scoring. A cosine similarity threshold of 0.75 was applied, enabling the model to identify sentences that are semantically aligned – but not necessarily identical – to high-risk patterns such as “project canceled” or “put on hold.”

Projects were classified as either at risk of severe delay or not at risk, with each flagged project also providing the specific sentence that triggered the classification. In this analysis, severe delay is defined as cessation of progress with no active recovery timeline. In practice, this typically corresponds to projects that have been inactive or halted for two years or more.

While the methodology is designed to minimize false positives through a conservative phrase bank and a high similarity threshold, it may still under-report risk in cases where language is ambiguous or where project updates are infrequent or missing. NLP-based methods can also struggle to interpret context or tone, which may limit their ability to detect implicit or cautiously worded signals of disruption.

Moreover, the underlying data is dependent on the accuracy of GlobalData’s reporting. These factors mean that while the NLP risk flags offer valuable insight into systemic delivery risk, they should be interpreted as directional indicators rather than definitive classifications.

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Industry leaders from across the globe

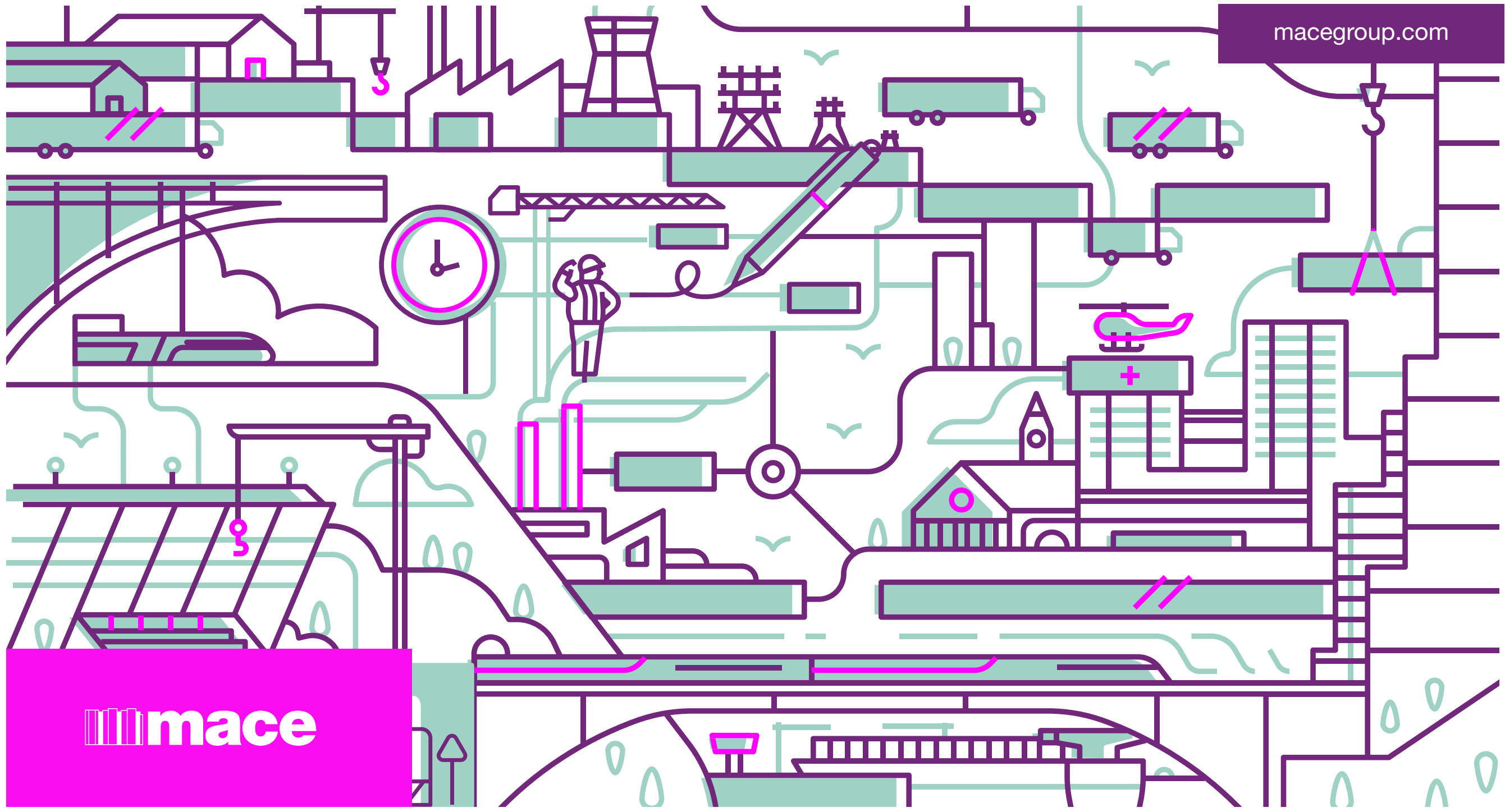
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- Ceri Evans, Director for Cost and Commercial Management, Global, Mace Consult
- Peter Hurst, Executive Director for Singapore and Hong Kong, Mace Consult
- Salma Abu Izzeddin, Program and Project Management Lead, MEA, Mace Consult

- Priya Jain, President, Mace Americas,
- Caroline Lassen, Director for Program and Project Management, Global, Mace Consult
- Helen Latham, PMO and Project Controls Lead, MEA, Mace Consult
- Zoe Madams, Director for PMO and Planning, Global, Mace Consult
- David Martin, Managing Director for APAC, Mace Consult
- Chris Mattock, Head of Sustainability for Infrastructure, Global, Mace Consult
- Jason Millett, Chief Executive, Mace Group
- Mark Reynolds, Executive Chairman, Mace Group
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