mace

INSIGHTS 2020

A BLUEPRINT FOR MODERN INFRASTRUCTURE DELIVERY

Why things go wrong and how to put them right

Jason Millett
CEO for Consultancy

Jason is responsible for our consultancy business and is driving our goal to be the leading global programme manager by 2022.

He has over 30 years' industry experience and leads on some of the UK's most significant projects alongside the largest global programmes. He was CLM's programme director for the London 2012 Olympic and Paralympic Games, responsible for the delivery of the Games venues and the commercial closure of the most successful Olympics ever. Prior to joining Mace he was CEO of Bovis Lend Lease.

Jason is currently overseeing many of Mace's largest projects and programmes, including the construction of Dubai Expo 2020, the delivery of Peru's reconstruction works in response to El Niño, the development of Keflavik International Airport, and the transformation of London's Euston station for HS2. He sits on the UK Government's Trade Advisory Group for Investment, is a member of the Heathrow Skills Implementation Steering Group and was an advisor to the Mayor's London Infrastructure Delivery Board. He is also a fellow of the Chartered Institute of Building, the Royal Institute of Chartered Surveyors and the Association of Project Management.

Davendra Dabasia
MD for International

Having worked on complex schemes across the globe and in a variety of sectors during a career that spans two decades, Davendra has developed extensive programme management and project delivery experience, with particular expertise in programme organisation, governance, controls and reporting, and construction management.

In more recent years, he has honed these capabilities through a close involvement with sports and events infrastructure and a lead role in growing Mace's transport infrastructure offering.

Davendra has been instrumental in Mace's international growth, having led the successful delivery of a number of overseas projects and programmes, in India, East Asia, East Africa and South America. In recognition of this, he became Mace's Managing Director for International at the start of 2020.

In this role, Davendra is responsible for overseeing Mace's consultancy work across its five international hubs and helping the business to grow in new overseas markets. Current programmes of note include Dubai Expo 2020, a major Tata Housing scheme in India, several healthcare projects in Sub Saharan Africa, and the Word Trade Centre in Kenya.

In 10 years' time we will be spending...

$5.25tn

...a year on infrastructure globally [ii]

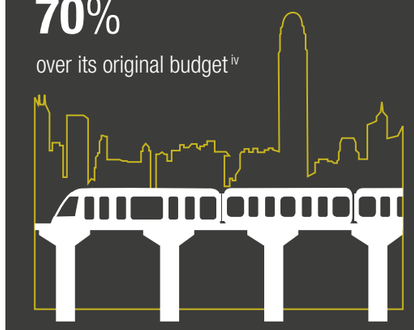
73%

of people across the world agree that investing in infrastructure is vital to their country's future economic growth [i]

The Bangkok metro project came in at...

70%

over its original budget [iv]



By 2030, the amount spent on infrastructure each year (USD) will be...[vii]

USA
$665bn

India
$513bn

Nigeria
$135bn

UK
$102bn

Australia
$96bn

Vietnam
$41bn

South Africa
$37bn

Peru
$28bn

Kenya
$22bn

Hong Kong
$17bn

Singapore
$5bn

The world has been shaken by the global COVID-19 pandemic. It is essential that economies around the world recover quickly to avoid permanent societal damage.

Good infrastructure has always been essential for growth and prosperity, but rises in importance during a recovery phase. At a fundamental level, basic infrastructure like clean water and sanitation prevents disease and premature death, while advanced infrastructure like 5G and small modular reactors can give economies a competitive advantage or help tackle climate change.

US$4 trillion needs to be spent every year globally to accommodate growing populations in emerging economies or to replace existing infrastructure in high-income nations. Asia, in particular, will need to gear up for delivery and learn from international expertise as it will account for more than half of global infrastructure investment over the next 20 years.

By 2030, India will be spending US$500bn a year to accommodate its rapidly expanding population, the USA will be spending US$665bn to maintain its status as a global super power, and Peru will be spending US$28bn a year to make it more resilient to natural disasters like El Niño.

Even so, the economic impact of COVID-19 may put new funding pressures on national budgets, which risks important infrastructure being stopped. While this may provide short-term relief, it will damage growth potential in the longer term.

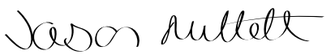
As time goes on, public concerns are moving from health to the economy.[1] 73% of people across the world agree that new infrastructure is vital to their country's future economic growth, with many governments seemingly agreeing. For example, Australia's Prime Minister has spoken about an 'infrastructure-led recovery', with recent revisions to the infrastructure priority list pledging more than AUS$64bn in planned spending.

A global infrastructure-led recovery will not be straightforward, however. A study by Oxford University found that 80% of all large projects globally experience cost or programme overruns. The Bangkok metro project, for example, came in at 70% over its original budget.

This does not mean these projects were 'failures'. If the primary outcome was regeneration, improved living standards or economic growth, they may be regarded as successful. Unfortunately, many large projects are born out of political circumstances and can lack clarity over the issue to be tackled, leading to muddled decision-making and projects becoming 'Frankenstein's monsters'.

Our modelling shows that, unless we improve how we plan and deliver large projects and programmes, taxpayers around the world could face US$1.9 trillion of unexpected costs at a time when budgets are already stretched due to COVID-19.

We have spoken to over 40 infrastructure leaders from around the world, have produced new modelling and have reviewed credible research to outline how projects can set themselves up for success, learn lessons from the past and maximise their much needed economic potential.



Jason Millett
CEO for Consultancy

Since the global COVID-19 pandemic took hold at the start of 2020, infrastructure delivery and its role in society has changed dramatically in nature. At the peak of the virus, governments around the world were concerned with rapidly increasing hospital capacity, while trains and buses fell silent as people were instructed to stay at home. But as attention turned to economic recovery, infrastructure's role as an enabler for growth has taken centre stage.

According to the World Bank[lviii] the impact of lockdown measures and behavioural changes in response to COVID-19 caused the most severe contraction since the Second World War. It anticipates that economic activity across advanced economies will shrink by 7% in 2020 and by 2.5% for emerging markets and developing economies.This will be their first contraction as a group in at least sixty years.

While there was a 73% drop[lix] in public transport use in India, a 50% drop in the United States, 65% drop in Australia and a 72% drop in the UK at the peak of the coronavirus outbreak, these figures are likely to be temporary and are already beginning to reverse in many cases under eased restrictions. Still, many networks around the world face longer-term strategic challenges with population growth ageing assets or low productivity.

Good infrastructure, delivered well, is nearly universally accepted as an enabler for growth and economic development. Not only does it provide direct employment and Keynesian stimulus but over the longer term it can open up new opportunities for local people, tackle climate change, provide businesses with a larger pool of skilled workers and remove congestion and constraints on the flow of freight, trade and goods.

Infrastructure investment is especially useful in challenging economic times because of its multiplier effect of between 0.4 to 2.2 times GDP per year and its jobs creation potential, with more than 10,000 new jobs for every $1 billion invested.[lx]

However, delivering such infrastructure during and after the pandemic could present a significant challenge.

Firstly we have the construction sector challenge. According to the World Economic Forum[lxi], the construction sector accounted for 6% of global GDP and the global workforce in 2019, while the pandemic has caused construction activity levels to fall by as much as 60%. At the same time, productivity has fallen by 25% to 40%[lxii] due to new health and safety protocols and limiting of numbers allowed on site.

This drop in output, forced site closures and ongoing restrictions means that many construction companies and supply chains will have suffered from constraints on cash flow, profitability and their ability to survive. Of course, this is impacted by the financial support available from different governments, which varies widely. If they haven't done so already, governments are being urged to take steps to protect their construction industries from pandemic impacts so that the much needed capacity to deliver will exist in the years to come.

Secondly, there will be potential funding challenges for large infrastructure projects over the coming decades. The G20's Global Infrastructure Hub suggests that, between 2016 and 2040, there will be a US$15 trillion funding gap for infrastructure. This will be compounded by the increasing national debts as a result of COVID-19. The IMF suggests that debt levels in the developed world will rise to US$66 trillion by the end of 2020, with emerging and developing economies' debt rising to US$55 trillion.

This 'debt crunch' could cause governments to cut infrastructure spending to address short-term operational funding needs, which will then likely have the knock-on effect of limiting future growth and delaying economic recovery. This will only make the situation worse.

It may be that we need a new generation of public-private partnerships to fill the funding gap while having open, transparent and early dialogue with the private sector to set realistic outcomes for projects. These discussions will need to consider phasing in order to spread costs, while urging private sector partners to use modern methods of construction where possible to improve speed of delivery, quality and potentially bring economies of scale.

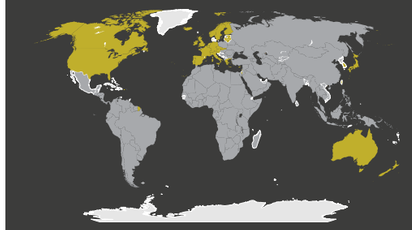
Given a potential squeeze in some countries on infrastructure finance and the general economic malaise expected, delivering infrastructure well has become even more important. As you would expect, many of the lessons drawn out in this report were from before the pandemic struck, but that does not diminish their relevance or importance. The only thing that, perhaps, has changed is a need to deliver schemes faster so that their benefits can be felt in the nearer term. This makes the need for clear leadership, innovation, phasing and the removal of unnecessary bureaucratic hurdles absolutely essential.

Many people have come together to tackle the challenges of the pandemic, doing things much better and more collaboratively than ever before to save lives and prevent healthcare systems becoming overwhelmed. Our sector needs to hold on to that spirit, along with the positives that have emerged from the new ways of working, if we are to support the next phase of our global response to the coronavirus and into recovery.

The IMF suggests that debt levels in the developed world will rise to...

US$66 tn

by the end of 2020



...with emerging and developing economies' debt rising to...

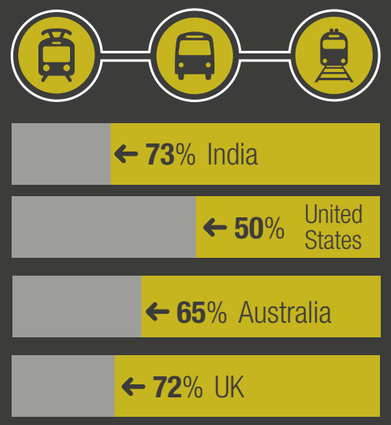
US$55 tn

Infrastructure has the potential to create...

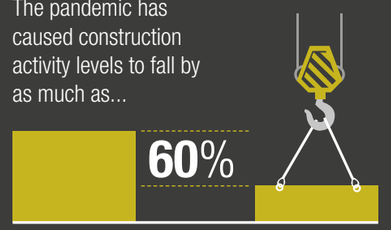
10,000

new jobs for every US$1 billion invested[lx]

The use of public transport dropped significantly during the peak of coronavirus[lxi]



The pandemic has caused construction activity levels to fall by as much as...



Productivity has fallen by...

25% – 40%

due to new health and safety protocols and limiting of numbers allowed on site[lxii]

INTRODUCTION

Infrastructure investment is critical to the success of the world economy – especially as we recover from COVID-19. It is widely accepted that good infrastructure enhances a country's economic potential. Well thought out transport infrastructure, in particular, can enhance mobility and promote agglomeration effects, while good energy infrastructure can provide economic security and deliver low-cost power to fuel wider industry.[vi]

By 2030, around US$5.25 trillion will be spent a year on infrastructure globally,[vii] with the USA predicted to spend US$774bn a year by that date, India US$432bn, Australia US$142bn and the UK spending US$86bn. In fact, according to Prof. Bent Flyvbjerg of the University of Oxford, UK, never in history has infrastructure spending been this high when measured as a share of world GDP.[viii]

And it is no wonder, given the correlation between the quality of infrastructure and a country's GDP.[ix] For example, according to the World Economic Forum, Singapore has the best quality infrastructure in the world and the highest GDP per person in the G20,[x] compared to Nigeria, which is ranked 130th for quality of infrastructure and 138th for GDP per person.

But we face a significant problem. The majority of large infrastructure projects around the world are delivered either late, over budget or under-deliver on the benefits they promised. In every corner of the globe you can see major projects grabbing the headlines for the wrong reasons, whether it is the Sha Tin-Central MTR Project in Hong Kong, the CBD and South East Light Rail project in Sydney, Crossrail in London or Berlin's new Brandenburg Airport, which is eight years late and €4bn over budget.

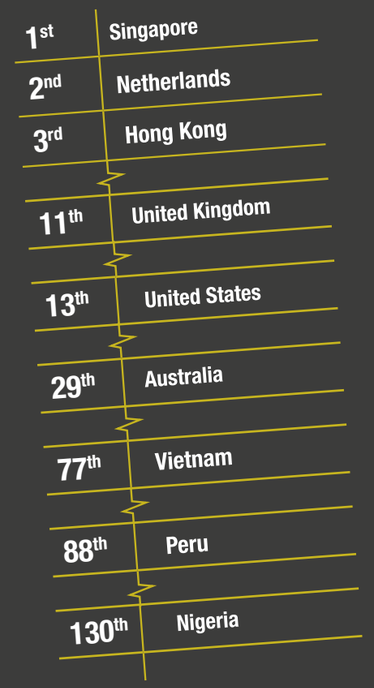
Globally, somewhere between 70–80% of large infrastructure projects go over programme or budget.[xii] This is evidence of a systematic failure in project planning and delivery.

This in part may be due to the scale and complexity of infrastructure projects more than doubling over the last century.[xiv] For example, the cost of the 4G Roads and Highway Programme in Colombia is equivalent to an economy the size of Iceland or Cambodia.[xv] It may also be due to a failure of accurately predicting costs and programme, human psychology, having the wrong people and culture, poor management or political interference.

This report looks at all these issues and more, in order to identify the major causes of failures, and also what exactly can be done to put them right. To help produce this analysis, we recruited the help of a large group of senior executives with experience of successful project planning, design and delivery of major infrastructure all over the world. Their experience ranged from major project management and oversight to senior roles in government, public infrastructure and delivery agencies.

Throughout this report we refer to 'infrastructure owners' rather than 'clients'. According to the UK's Institution of Civil Engineers, the word 'client' implies a transactional relationship that we want to move away from. Infrastructure owner is used to cover both private and public sector organisations.

Global infrastructure rankings [x]



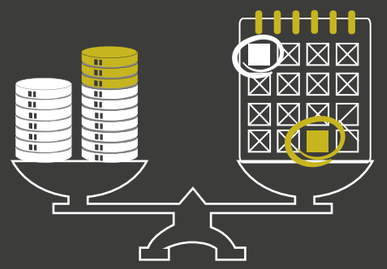
The cost of Colombia's 4G Roads and Highway Programme is equivalent to an economy the size of Cambodia. [xv]

When Berlin's new Brandenburg Airport opened it was…

8 years late and... **€4**bn over budget [xi]

80%

of all large projects globally experience cost or programme overruns [iii]



CLARITY OF OUTCOME

"Unless you're absolutely crystal clear what the outcome you want is, you get organisational spinning and chaos."
Tom Samson, former COO of Emirates Nuclear Energy Corporation

When setting out strategies, most projects, politicians and companies unfortunately end up with what Prof. Richard Rumelt calls "bad strategy":[xvi] *"vague and meaningless statements, full of fluff, failing to make any real choices to address the challenge in question and mistaking grand ambition or goals for a strategy."*

The tomes of 'strategic' documents produced may seem impressive and sophisticated but, in reality, a hallmark of true expertise and insight is making a complex subject understandable.

When the former US Secretary of Transportation, Anthony Foxx, gave an interview before leaving office he said that he was "*most excited about our country [the USA] getting transportation right".* 'Right' being the key word. Not building a new road or railway for the sake of it, in the vague hope that it will help in some way, but properly thinking about the real issue that needs to be solved and the outcome that means success.

For example, Hyderabad – which is India's fourth largest city – has been growing at a tremendous rate, with its population nearly doubling in the last 20 years. This has caused a significant strain on the city's infrastructure with half a million cars being added to its roads every year. This resulted in public pressure to improve journey times and global pressure to reduce carbon emissions and become more sustainable. In 2008, Hyderabad Metro Rail proposed an ambitious rapid transit scheme to meet those challenges. A Public Private Partnership was created in 2014 between the state government and its private partner. The scheme was built to accommodate 60,000 users an hour, reduce journey times by up to 70% and reduce carbon emissions by 3,100 tonnes a year.

The focus of the project has been on the people who use it. Convenience for commuters and appealing aesthetics have both been considered, and, most importantly, many of its stations are connected to main railway stations, allowing switching between modes of travel.

At the end of 2018, the scheme was judged to be the Best Urban Mass Transit Project by the Government of India. The scheme proved so successful that its use has exceeded the highest forecasts, with Phase 2 of the scheme currently in delivery.

Major projects need to decide on what outcome they are looking for, and challenge every decision made so that they are coherent with that outcome. Projects that are created on a whim, without proper thought, are much less likely to be successful. As a senior infrastructure owner told us, *"root causes of problems almost always comes back to clarity of outcome and what the client wanted was not clear."*

This is a particular challenge for some politicians who might, for example, ask for a road to be built between point A and point B, rather than thinking about the outcome to be achieved and then developing a scheme which delivers on that. With that thought process you may actually decide a railway is better than a road, or that a junction improvement is a good idea, or that some other solution is actually the answer to deliver that outcome.

Fighting entropy

Entropy is part of the laws of thermodynamics, but what on earth does it have to do with delivering infrastructure projects? One of the ideas to explain entropy is that, if left unchecked, a system (or organisation) gets more disordered and chaotic over time.

This is the same with any large project or organisation. While the outcome may be clear at the start of a project, over time that clarity can often become blurred. Major projects are often characterised by ambiguity and at that point consistent visionary leadership is necessary to drive effective progress. As George Mueller, the Director of Manned Space Flight for NASA's Apollo missions said back in 1963: *"So many programmes fail because everybody doesn't know what it is they are supposed to do and what the priorities are."*

More thinking upfront

"Unfortunately, many projects can be rushed and start without people thinking through the detail and the consequences."
Carlos Alberto Neuhaus Tudela, Executive Director of the 2019 Pan and Parapan American Games, Lima, Peru

Regrettably, the way that many major projects around the world are funded means that too little time, thinking and rigorous process go into the start of the projects. The traditional (and outdated) approach to planning a major infrastructure project generally goes something like this: the client has a broad idea of what they want delivered (not the outcome, but a 'product') and get a small amount of funding to investigate, they get a bit more money to bring in cost consultants and engineers to produce a concept level design of the scheme, predict the price and how long it will take to build, some more money is given for further design (often by some different engineers or designers) and the relevant planning is sought, once permission is granted the design goes out to contractors or civil engineering companies to deliver.

One problem with this approach is that at each stage of the journey, a different set of suppliers is brought in with little or no continuity between them. This can promote a 'I will just look after my phase and someone else can fix it later' culture, rather than everyone acting in the best long-term interests of the project.

The other problem is that, in the words of one senior infrastructure executive, *"90% of savings and innovations actually come within the first 10% of project spend."* With projects often focused on progressing to the next stage as quickly as possible to secure more funding and 'early wins', many innovations are overlooked at the beginning and then prevented from being introduced at a later date by the constraints imposed in earlier stages and the resultant planning process.

Major infrastructure projects are complex systems and, as the life of a project goes on, the capacity for innovation is reduced as the constraints inadvertently built into the project in its earlier stages hamper innovation (see Figure 1).

In the early stages, projects should be defined in terms of ranges of measures and then developed to prove their case within that range, as opposed to being defined in absolutes at the start and then always failing to achieve that specific programme, cost or performance criteria.

Many governments around the world are rightly concerned about wasting taxpayers' money. However, by skimping on the thinking in the early stages to save money on projects that do not go ahead, they actually produce a false economy where projects that go ahead are not as well thought out as they should be. Failing to think through the best way to achieve the desired outcome and building in space for innovation costs the taxpayer significantly more in the long run.

Let us be clear, we do not mean endless prevarication and lack of decision making in the planning stages which unnecessarily drags things out. We still need to approach the early thinking in a systematic and managed way, but also be willing to consider the options and critically challenge their assumptions. Infrastructure owners need a systematic way to go through the stage gates and manage design from day one. We have found that poorly run programmes only start a proper process of management half-way through the early stages.

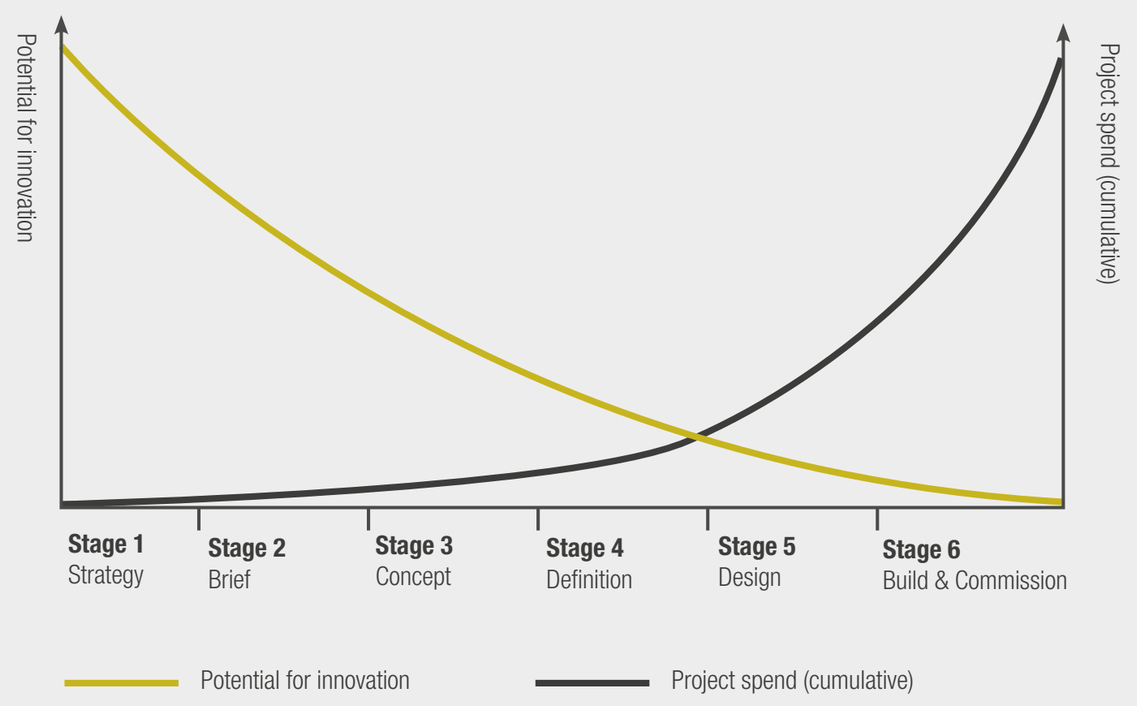
One way to increase thinking up front is through the better use of simulation and modelling (for example Level 3 Building Information Modelling) to get ahead. With the right digital tools, you can test how a piece of infrastructure may operate for a range of different conditions and how it will sit within its environment. This can help to shape the project's evolution and experiment with how innovations can be made.

Many projects around the world do not invest sufficiently in their digital testing capabilities which in other sectors has given companies the edge to get ahead.

Take for example how the graphics chip manufacturer Nvidia invested heavily in the digital testing of its chips to get a competitive advantage over the tech giant Intel in the 1990s, quadrupling their profits in the last 10 years.

Fig. 1

90% of possible savings and innovations come within the first 10% of project spend



CASE STUDY: NVIDIA VERSUS INTEL

HOW DIGITAL TESTING CAN GIVE YOU THE EDGE

Unless you are a gamer or take a keen interest in technology, you probably do not know who Nvidia is. From a standing start, the company managed to carve out around 20% of the 3D graphics chip market,[xvii] now employing over 11,000 people worldwide and with a market cap of nearly US$100bn.

With the rise of PC computing power in the 1990s it was starting to become clear that home computers would soon be capable of rendering 3D graphics. At that time, many Silicon Valley companies were thinking about a 'multimedia revolution'. So Nvidia's first product was the NV1, which was focused on improving audio quality while providing some 3D graphics support. It was a flop.

Intel, the major incumbent, was too powerful and dominant compared to Nvidia who was struggling to produce anything that was more powerful or with significantly better performance.

The company's CEO Jen-Hsun Huang established a temporary technical advisory board of both insiders and expert outsiders to critically diagnose the challenge they had in front of them and provide a coherent response to the challenge.[xviii]

Instead of multimedia, the company would push hard on 3D graphics for desktop PCs.

Progress in the semiconductor industry is largely driven by reducing the size of the transistor on the chips. Smaller transistors mean more power and better efficiency. The rate of progress in computing power is called Moore's Law. Because of the interdependencies involved in chip production it was thought that the processing power of a chip would approximately double every two years.

Nvidia decided that it must be possible to break out of this two-year cycle. A serious source of possible delays was in the design process: inadvertent errors or clashing designs that then caused significant performance problems.

After designing a chip, it was sent off to a 'fabricator' (the construction company of the chip-making world) who actually created the component. According to Prof. Richard Rumelt: *"After about a month, engineers received back the first samples of the actual chips. If bugs were found in these chips, the design would have to be changed... and a new fabrication run initiated."*[xix]

The leadership of Nvidia recognised that this was a wasteful and productivity sapping way of doing things. There had to be a better way.

They decided to invest heavily in emulation and simulation techniques to try their best to prevent design issues from happening in the first place. This included simulating the quantum mechanical or electrical effects that could interact with unintended consequences.

Investing heavily in their digital tools was a major factor in Nvidia's ability to cut their new chip production time from around 18 months to six. This meant they could innovate faster than their competition, resulting in the US$100bn company that we see today.

Nearly...

90%

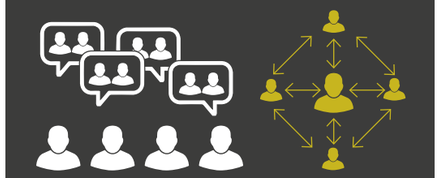
of infrastructure owners feel the need to bring in outside people to help [xx]

80%

of organisations talk about collaboration...

20%

actually do it



IT'S ALL ABOUT THE PEOPLE AND YOUR CULTURE

"After knowing the outcome you're trying to achieve, you then need to make sure you have the right people with the right behaviours to achieve it."
Tony Chisnall, Director Capital Programmes, Schiphol Airport, Amsterdam

No matter how many processes you develop, how accurate your forecasts are, how you structure your project or how many awards you have, success ultimately comes down to whether you have the right quality of people, with the right attitudes, at the right time, working on your project.

Honesty in your capability

Infrastructure owners and their supply chain need to be honest about what capabilities they each have, and how people can effectively form a high performing team that complements each other.

One of the issues raised by the Engineering News Record in the USA is that *"many owners are not equipped to handle the complex choices they face in the construction process from the earliest stages through delivery of the finished project"* which makes the statistic that nearly 90% of infrastructure owners feel the need to bring in outside people to help,[xx] not that surprising.

This means that infrastructure owners often need the help of advisors and partners to complement and bolster their internal team. The challenge is that traditionally different suppliers are brought in at different stages for only their section of the work, leading to a fragmented approach and, sometimes, the wrong behaviours being displayed. It is far better for large infrastructure projects to find a long-term trusted partner who is involved on the project from start to completion and who can be the consistent presence, integrating and bringing together the different suppliers as required and is incentivised on the successful outcome of the whole project rather than one discrete element.

The UK's Institution of Civil Engineering calls this long-term partner to the client an 'integrator',[xxi] NASA a 'systems engineer'.[xxii] Whatever you call the role, it is integral to successful major project delivery and to helping infrastructure owners to become intelligent clients who have clarity of outcome in what they want, keep that focus and balance necessary trade-offs against the intended outcome while managing the performance of suppliers and advisors.

Capability does not mean more people. It means having the right people at the right time. *"One talented person can do the job of 10 mediocre people,"* were the words of one senior infrastructure executive we interviewed. Growing teams too large can also actually cause more challenges than benefits. Increasing a team's size can hamper its coordination, diminish its members' motivation,[xxiii] and increase conflict among team members, which clearly affects project culture too.

Culture & leadership are key

"80% of organisations talk about collaboration, 20% actually do it."
Major UK infrastructure owner

Getting the right individuals together on the project is the first step; the next is how to create the right culture for those individuals to become a high performing team.

You want a culture where everyone (client, stakeholders and supply chain partners) understands the desired outcome, any problems that need to be overcome, where people feel ownership and that their contribution is making a difference, and where any issues encountered can be escalated to management who all understand the problem and can collaboratively work together to overcome it.

From our interviews, there are some common themes that have emerged to give projects the best chance of getting their culture right:

1) Ensure that procurement includes in-person interviews, competitive dialogue or some other type of behavioural assessment. If done well this can give an idea of how people might behave on the project and the partner organisation's culture. Procurement needs to incentivise alignment between the outcome, culture and a true partnership.

2) Keep the project or programme board (or senior executive team) as small as possible. Research by Hackman and Vidmar[xxiv] shows an optimum group size is five and research published in Harvard Business Review showed that every person you add after seven reduces effective decision making by 10%.[xxv]

3) Repeat, repeat and repeat again the outcome that the project is expected to deliver. While you might be clear on the outcome at the beginning, as people come and go and the project progresses, that can become less clear and people forget the purpose of the project

4) Collaboration means being honest and sharing and solving issues with the team. It does not mean saying that 'everything is fine' when in reality it is not. The project structure needs to encourage effective communication and not overreacting to 'bad news'. Clients play a key role in setting the right collaborative behaviours.

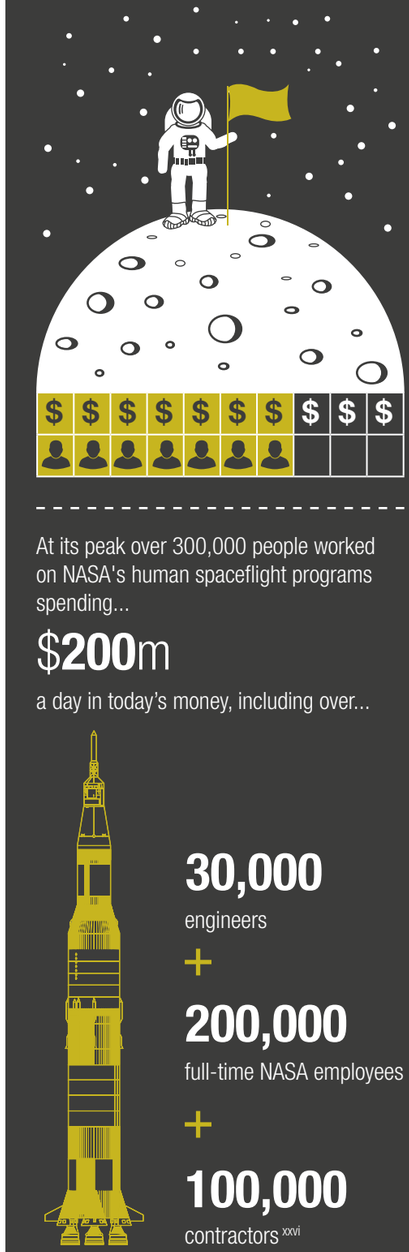
5) Particularly in emerging countries, procurement needs to be transparent and done in an open way to try and tackle corruption.

6) Project leaders should be visible and build appropriate relationships with senior executives within supplier organisations. Project leaders should regularly take the project board out of the infrastructure owner's office and to the different suppliers involved in the project. This shows willingness and can help to break the 'us and them' culture.

Taking a programme as large as Apollo, for example, the Director, George Mueller, saw establishing communications up and down the line as a critical success factor. He wanted information to flow from the shop floor 'all the way to the people that were managing'. Improving communication was a prerequisite to enabling 'all of us to understand what was going on throughout the program'.

70%

of the cost of landing a man on the moon was spent on people



At its peak over 300,000 people worked on NASA's human spaceflight programs spending...

$200m

a day in today's money, including over...

30,000
engineers

+

200,000
full-time NASA employees

+

100,000
contractors [xxvi]

CASE STUDY: NASA'S APOLLO SPACE PROGRAM
THE IMPORTANCE OF PEOPLE, COMMUNICATIONS AND 'SYSTEMS ENGINEERING'

Landing a man on the moon and returning them safely to earth is undoubtedly one of the greatest technological and complex of human achievements. At the time, being the first country to put a man on the moon was a matter of national pride and a major propaganda coup against the Soviet Union. It later became a memorial to the memory of President John F. Kennedy and simply could not fail.

The little known person who deserves much of the credit for the USA's success is George Mueller, the Director of Manned Space Flight at NASA from 1963 to 1969. According to author Arthur Slotkin, it was *"Mueller who made it possible to land an astronaut on the moon within the 1960s".* When appointed, Mueller had no experience in human spaceflight (very few did) but he was an expert in satellite communications with experience managing research and development for the American Air Force's ballistic missile programme.

Mureller took over the program after his predecessor D. Brainerd Holmes was fired because of tensions with NASA's head James E. Webb. When he took over schedules were not integrated, the different teams were at loggerheads fighting for position and costs were out of control. In Mueller's own words *"There wasn't a difficulty you could imagine that wasn't in the forefront of things at the time...we had problems with everybody."*

At its peak over 300,000 people worked on NASA's human spaceflight programs, spending $200m [xxvi] a day in today's money across three centres (Space Task Group, Marshall Space Flight Center and Launch Operations Center). This included over 35,000 engineers, 200,000 full-time NASA employees and 100,000 contractors. 70% of the total cost of the program was spent on people.

When Mueller arrived he found a 'cadre of people that were not gifted' on the project and took swift action to ship as many off the project as quickly as possible. His philosophy of management was about finding people who were the best in their field and that he could trust. He began with the people immediately around him: the directors of the three centres. He made sure they could handle what they needed to do and then made sure that the next layer was tied into the first layer, and so on.[xxvii] Over the life of the program NASA retained continuity by assigning experienced program managers to fill roles particularly getting people from the military.

He paid particular attention to the recruitment of those he called 'systems engineers'. Systems engineers were a special kind of person who could visualise how the different elements of the program were chain-linked together and how one decision might impact another. They needed a real depth of understanding of the whole program. They influenced what actually happened, assured the adequacy of designs and examined contingencies and trade-offs. System engineers combined with program controls is what the UK's Institution of Civil Engineering today would call a 'project integrator'. These individuals were absolutely critical to the success of the Apollo program.

For a program as large as Apollo, establishing effective communications up and down the line became a critical success factor. Mueller restructured the organisation introducing a 'GEM box' (named after his own initials) management structure where daily communications could happen between NASA HQ and each of the separate streams of work without having to go through the center. He wanted to create a culture where people had clarity of the priorities and any issues would rapidly go to the top. He said *"the thing that kills programs is not knowing that this small piece over here failed a test yesterday, not last month. And... daily communications down those five parallel lines (the different functional areas) is probably the most significant contribution to getting the program done that I know of."*

Continued on next page

He didn't just end with ensuring effective communication between functional areas, he also looked to the contractors and the three center directors. He needed to improve communication, from the shop floor 'all the way to the people that were managing'. Improving communication was a prerequisite to enabling 'all of us to understand what was going on throughout the program' and understanding the outcome.

Mueller's predecessor, Holmes, had established a Management Council consisting of 14 members from the three centres and various other areas within NASA. It had tended to be a 'debating society' rather that an effective management tool to help solve problems. Mueller cut the number of attendees by 10 to four, including him. He turned the Council into a forum for sharing and solving problems together rather than a talking shop.

With 100,000 contractors (i.e. all the people within their supply chain) working on the project Mueller regularly met with the contractor's most senior executives, providing his view of what the other workstreams and contractors were doing and what the overall problems were.

He created an Apollo executives group for major supplier CEOs to get them immersed in the program and understanding their firm's responsibilities, which increased their interest and support in achieving the desired outcome and goals.

Mueller would also regularly call up supplier CEOs. For example he would regularly call the CEO of Boeing and ask what had gone wrong with the engine valves. The first time it happened the CEO had little knowledge of what was happening, by the third time they were much more up to speed.[xxviii]

He held regular meetings at the contractor's plants, offices and at NASA, so that supplier CEOs could understand the challenges of others while also seeing how well some were doing compared to their own organisation. He spent half his time visiting the three centers and the contractors to just 'see what was going on' and 'identifying any weak spots' on the ground.

Mueller wanted NASA's supply chain to be fully part of the programme team with their CEOs involved enough to hold their organisation's focus and help solve problems. Plus he saw his role as being at the 'coal face' and spotting potential issues.

George Mueller's focus on getting the right people, supported by an empowering structure that promoted communications at all levels, with systems engineers acting as the glue that held the project together and decided on trade-offs, saw Apollo 11 land on the moon on the 20 July 1969 living up to President Kennedy's pledge to the nation and moving the human race into a new era.

The Apollo 'management council' had tended to be a debating society, so Mueller cut the members from...

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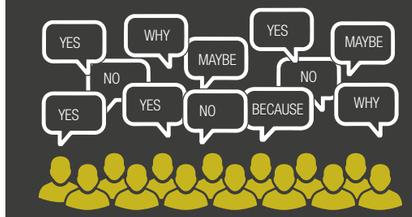

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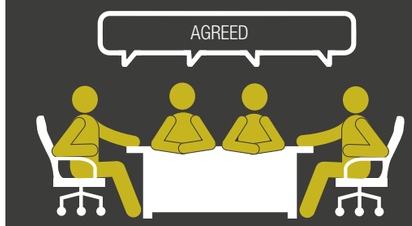


…creating an effective management tool to help solve problems quickly

"A lot of people think if you just had more process and more compliance—checks and double checks and so forth—you could create a better result in the world…. We just try to operate in a seamless web of trust and be careful whom we trust."
Charlie Munger, Co-Founder of US conglomerate Berkshire Hathaway

When you are spending very large amounts of taxpayers' or investors' money you, of course, need process, governance and checks. But if you're not careful, you can strangle the performance of the high calibre team you have put in place by tying them up in unnecessary rules, reports and committees. Resulting in further costs for the project funder. This was a common point of grievance in the series of interviews we conducted for this report.

Many poor governance frameworks and supporting systems start from the premise that the people you have selected to work in your organisation (whether directly employed or in the supply chain) may be 'self-interested and willing to take actions to further their own interest at the expense of the organisation.'[xxix]

This kind of distrusting mindset causes a lot of energy and time to be spent on extensive and onerous procedures to monitor the actions of those you have already supposedly decided (through a recruitment or procurement process) are good people who you think will work well on the project. It can build up resentment, frustration and reduce team morale, which then impacts productivity. By focusing on employing and working with people you trust you can reduce levels of bureaucracy to those that are essential, make employees feel more ownership and cut wasted time and money.

Infrastructure owners and sponsors need to acknowledge that mistakes and issues will happen and more layers of process will not solve that.

The crucial factor of a 'trust-based system' is finding the right project or programme director. Infrastructure owners need an executive 'of high capability and sound integrity' who 'can be relied on to make correct (rational) decisions in the long-term interest of the organisation and the project'.[xxx]

From our research it is clear that some organisations and projects have included the involvement or approvals from people and committees simply because nobody is willing to take a decision themselves or willing to be accountable or willing to have the difficult conversations with those who are actually surplus to requirements.

As Charlie Munger says about Berkshire Hathaway: *"we want very good leaders who have a lot of power, and we want to delegate a lot of power to those leaders… I always like the systems where really good people get a lot of power and exercise it well."*[xxxi]

Of course with power must come accountability and there has to be consequences for failure. The former Columbia University philosophy professor Charles Frankel believed that *"truly responsible, reliable systems [or equally governance or processes] must be designed so that the people who make the decisions bear the consequences."* From our interviews, when projects find this balance they have better chance than not of succeeding.

Infrastructure owners need to set clear parameters for their project teams, establishing delegated authority, sensible gateways, change control and reasonable reporting requirements. Then give them the freedom to work within that remit.

Many organisations have created complex governance structures of many boards, committees, steering groups and projects boards in the false hope that these many layers will somehow improve the end outcome. This is a fallacy. Instead, organisations should focus on the simplification and reduction in procedures and finding responsible competent leaders that they can trust, empowering them and ensuring they face suitable consequences for failure. This should result in the speeding up and improved effectiveness of project decision-making.

"Procurement is probably one of the most indispensable elements of a truly capable state…without effective procurement, hospitals wait for drugs, teachers for textbooks, and cities for roads.

Lack of transparency and corruption in procurement directly affects citizens, and the losses to corruption are estimated in the billions of dollars every year."
The World Bank

The most common issue that came up during our interviews was procurement and, specifically, the many poor procurement processes that people have experienced as either clients or private companies bidding for work.

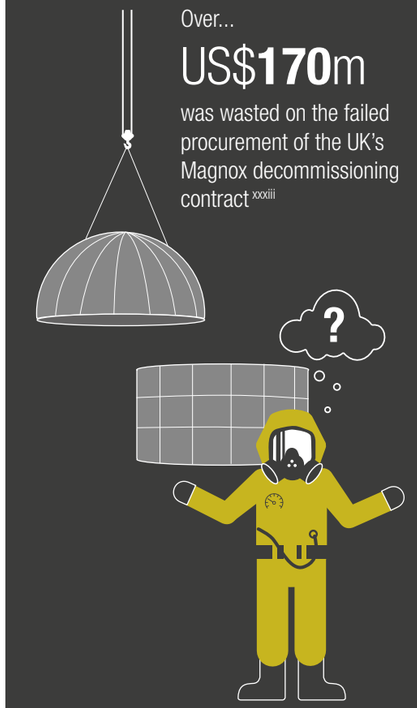
One senior transport executive we interviewed with experience of projects around the world, both in the public and private sector, said that *"good procurement is much harder than many people appreciate and sometimes tougher than delivering good construction. In emerging markets there is also particular concern about tackling corruption and improving the transparency of the process and contract awards to combat this."*

Poor procurement outcomes are often less visible and obvious to the public than challenges to procurement process through the courts, for example, but that does not mean they don't have a significant cost to the taxpayer or impact projects. One of the most notorious examples comes from the UK: the Magnox contracts. The Nuclear Decommissioning Authority (NDA) was established in 2005 as an arms length government body responsible for the operation, decommissioning and clean-up of 17 nuclear sites across the UK. This included 10 'Magnox' sites (a company created in 1996 to take ownership of various nuclear reactors around the UK).

For over two years the NDA ran a complex procurement process for £6.2bn of services to decommission two of the 10 Magnox sites over 14 years. At the end of 2014 the contract was awarded to Cavendish Fluor Partnership (CFP). Nearly three years later, in March 2017, the UK's Secretary of State for Energy announced that the contract with CFP would be terminated nine years early saying that *"it became clear to the NDA that there is a significant mismatch between the work that was tendered for and the actual scale of the work that is required to be carried out."*[xxxii]

The procurement process was also challenged in the UK's High Court by the large US corporation Bechtel, a losing partner in one the consortiums bidding for the work. The court ruled that the NDA had wrongly decided the outcome.

In total, over £130m (US$170m) was wasted on the failed procurement of the UK's Magnox decommissioning contract[xxxiii] which includes the payment paid to CFP for terminating the contract early and the settlement paid to Bechtel and their consortium partners.



Over...

US$**170**m

was wasted on the failed procurement of the UK's Magnox decommissioning contract [xxxiii]

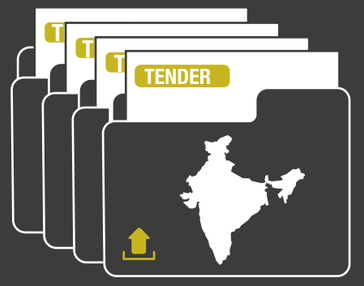
Over...

40%

of public spending in Australia and Korea is on private sector services [xxxiv]

Over the last five years more than...

2m



tenders have been issued across India [xxxv]

Procuring private sector organisations in the right way is a truly global challenge and has major impact for taxpayers around the world. Over 40% of public spending in Australia and Korea is on private sector services while in the USA and Columbia the figure is 25%[xxxiv] with over two million tenders being issued over the last five years across India.[xxxv]

Clearly, running procurement exercises can be a complex and formidable task, but the evidence from interviews we conducted produced a number of overriding success factors that commissioners and procurement professionals should think about:

The essential ingredients

According to work by the UK's Institution of Civil Engineers, there are six commercial principles which need to be in place to create the right environment for what they term a 'high-performing enterprise' i.e. a high performing project, organisation or team.

1. Alignment – where commercial performance measures are aligned to delivery of outcomes for the customer/end-user.

2. Reward – where reward mechanisms are based on the value brought to the project or programme and exceed expected outcomes.

3. Risk – where risks that the infrastructure owner or investor are accountable for are not inappropriately transferred to the supply chain.

4. Engagement – where the enterprise comes together at a much earlier stage in the asset enhancement/creation life cycle.

5. Scale – where the enterprise model yields the greatest benefits when applied across asset systems/portfolios.

6. Time – where the relationships between organisations last over a longer time period so that they have time to mature and become less transactional.

Our interviews and research then dug into more detail on these, as well as some other points:

Leadership

"Procurement processes led by the procurement department usually end badly. You need strong involvement and leadership from someone senior on the project delivery side."
Senior Infrastructure Executive

The project or programme needs to be crystal clear on the outcomes desired, the leadership's own capability and what it is looking for from an outside delivery partner or integrator. The best procurement processes we have come across have had the infrastructure owner's project director driving and leading the procurement.

Alignment and trust

"Only 32% of infrastructure owners have a high level of trust in their contractors."
KPMG Global Construction Survey

The best relationships are built on trust, where the contractual and legal words agreed take second place and people act as a cohesive team in the best interests of the project. Given the historically adversarial nature of construction in many parts of the world it does require a change in mindset on behalf of both infrastructure owners and suppliers.

This culture comes from the top down, and needs the right contractual agreements to promote the right behaviours. For example, under NEC3 contracts the supplier needs to flag issues early to their clients to try and solve them more collaboratively and build trust. Another case is the GC21 contract in Australia; for its flaws, this has been designed explicitly to try and promote cooperation and build trust between parties.

Another key issue to consider is the alignment of incentives right the way through a project. If the programme director is incentivised to deliver the project by a certain date, so should the integrator and other supply chain partners. If you have this coherence, you increase the chances of everyone working to the same goals and outcome and promote collaborative problem-solving.

As well as incentives, many contracts include penalty clauses. Where these are used, many of those we interviewed argued that the point and severity at which they kick in needs to be more carefully thought through. When things are only mildly going off-course, for example, harsh penalties can actually disincentivise people to solve the underlying problem and reduce team alignment.

Risk

"It's very difficult to be successful if you take no risk. You need to be aware of it, cost it, manage it and be realistic that many risks ultimately have to sit with the client. You also need to weigh up the effort of minimising a risk versus it actually happening."
Anuj Puri, Chairman, Anarock Group, India

A major sticking point in many procurement processes is infrastructure owners understandably trying to move risk from themselves to their supply chain, but doing so in an unreasonable way. As Sir Peter Hendy, Chairman of the UK's rail infrastructure manager, Network Rail, told us *"there is a lot of misunderstanding in governments around the world about the way you can pass off risk to the private sector."*

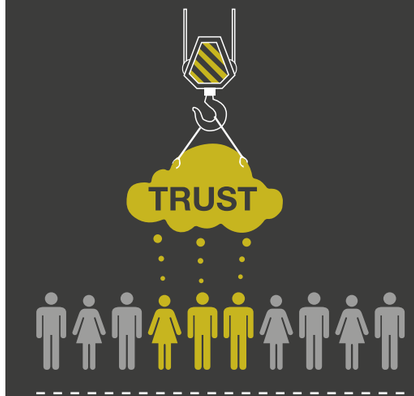
This can often lead to severe problems like unlimited liability being included in contracts which if enforced would in fact put the private sector organisation out of business and hence in reality give a false sense of security to the infrastructure owner.

From our interviews, most people felt that where there is an honest discussion about the risks that can be passed on and those that

Only...

32%

of infrastructure owners have a high level of trust in their contractors



15%

of global corruption and bribery cases relate to construction [lvi]

cannot, a fair solution can be reached that works for both parties and does not put off potential external partners or give false assurances to client organisations.

Speed of procurement

"Procurement teams tend to rely on processes that are far too slow to support the business's needs. That's just not acceptable in today's fast-moving and interconnected environment."
Harvard Business Review

Many procurement processes, particularly in the public sector, go on for many years before decisions are reached. Often the delays can be caused by overly risk-averse organisations that lack clear leadership, a realistic assessment of the risk impact of going so slowly or because the intended outcome is not clear. This delays getting the right partners involved and delays the start of the work; ultimately delaying the completion of projects.

Effective early engagement

"The procurement process saw the New South Wales Government interactively engage with proponents during the bid process to provide feedback and answer questions before formal bids are submitted."
New South Wales Government Action Plan, June 2018

Whether it is early conversations with potential partners or getting the right people involved earlier in the process, this was a key aspect identified in our interviews as a success factor.

Of course, this can take a number of forms and varies by project, but most commonly this involves a contractor (or those with the practical buildability expertise) working closely with the infrastructure owner through the initial stages of the project.

The contractor/partner then works with the client to develop the design and cost models (a risk-adjusted price) in parallel. Involving the contractor in this process can enable both the client and the contractor to appropriately allocate risk, reduce costs and promote more innovation.

True collaboration

Collaboration does not mean agreeing all the time. It means simply that you have a culture where people act fairly, have honest conversations and speak up at the first sign of an issue – and others then help them to solve it.

There are a number of contract models out there that try and achieve this, the most established being 'alliance contracting'. Alliance contracting is characterised by a number of key features, which generally require the parties to work together in good faith, act with integrity and make best-for-project decisions. The alliance participants work as an integrated, collaborative team to deal with key project delivery matters.

Under alliance contracts, risks of project delivery are often jointly managed by the parties, although financial exposure mostly sits with the infrastructure owner (see previous point on risk).

People can often test an organisation's appetite for real collaboration through so-called 'competitive dialogue'. This is where teams bidding on the work are put through a range of exercises and interviews to test how they may behave on the actual project. If done well, this can be an excellent and valuable part of the procurement process.

Tackling corruption

The OECD Foreign Bribery Report shows that more than half of foreign bribery cases were to obtain a public procurement contract and 15% of those were related to the construction sector (Ref: OECD Foreign Bribery Report, An Analysis of the Crime of Bribery of Foreign Public Officials, 2014).

Reducing levels of corruption is a key part of the UN's sustainable development goals, is important to voters and helps to encourage international businesses to become involved in local markets.

The World Bank views increased transparency through the use of e-procurement and laws in developed nations, which have international reach, as crucial for reducing corruption.

One of those we interviewed also advocated getting a country's national audit office, inspector general or equivalent closely involved in an oversight capacity from the start of the very largest public procurement contracts.

CASE STUDY: BANK STATION UPGRADE, LONDON UNDERGROUND
THE BENEFITS OF OUTCOME BASED PROCUREMENT

London's tube network is the world's oldest mass transit system and carries more than one billion passengers a year, on 11 lines with 270 stations.[xxxvi] It is a complex interdependent system and as the population of London continues to grow the ability of the mass transit systems to accommodate demand is a significant challenge.

Transport for London (TfL) has invested significantly in a programme that is aimed at delivering the extra capacity needed. Learning the lessons from past projects, they decided to try something a bit different: outcome based procurement which they refer to as 'Innovative Contractor Engagement'.

Outcome based procurement is significantly different to traditional approaches and is becoming increasingly used across a range of industries. It allows an organisation to select a supplier based on their ability to deliver against a set of outcomes, rather than specifying a large number of technical requirements, which can give little room for innovative proposals from potential suppliers, place an increased risk on the procuring organisation or drive an adversarial relationship with increasing costs when items fall outside of scope.

With the main objective of improving efficiency, procuring better value, expertise and innovation, the £625m major network capacity upgrade at Bank Station provided TfL with the opportunity to implement outcome based procurement on a large and complex scale.

Bank Station is in the heart of the City of London (a Central Business District of London) and currently serves 52 million passengers a year. Remaining fully operational throughout the improvement scheme, which is scheduled to finish in 2021, the project intends to support economic growth, allow the station to handle 40% more passengers,[xxvii] decrease crowding and congestion, improve the quality of access and future proof it for population growth.

Under a traditional procurement approach, TfL would have undertaken a technical review of the station and appointed an external consultant to then design and cost a solution. Contractors would then be invited to tender on the design and be appointed based on their ability to deliver the most cost-efficient solution. Using an outcome based procurement process, TfL asked bidders to develop designs that achieved the highest cost-benefit ratio rather than specifying a scheme for them to deliver. They agreed to pay contractors for any innovations put forward during the procurement process, even if they were not actually appointed to then deliver the full contract. Incentivising innovation and encouraging contractors to improve the product and designs promotes an industry-wide innovative culture creating more efficient solutions.

Through the outcome based procurement process, TfL appointed Spanish Design and Build contractor Dragados to deliver the Bank Station upgrade. Dragados have been tasked with delivering improvements including a new station entrance, a new Northern Line rail tunnel and platform to reduce interchange times and three new lifts with twelve new escalators. Miles Ashley, the former Construction Director for TfL on Bank Station said that *"on the Bank Capacity scheme, structured early engagement with the supply chain, coupled with an outcome evaluated procurement approach led to a 45% increase in value for the taxpayer compared to TfL's previously proposed scheme"* and that *"it's an approach that would undoubtedly benefit other infrastructure owners".*

With infrastructure projects becoming larger, more complex and more interdependent, in many situations it makes little sense to try and specify a complex list of requirements and outputs that a supplier has to deliver against. This is especially true when considering what organisations are procuring today for final delivery 10 or 15 years into the future when technology and products will have changed.

"The only function of economic forecasting is to make astrology look respectable."
John Kenneth Galbraith, Harvard Economist and US Presidential Medal of Freedom Winner

From 1984–2004 Prof. Philip Tetlock of the Wharton School at the University of Pennsylvania conducted a groundbreaking study. He found a group of nearly 300 experts from fields ranging from economists, senior civil servants to journalists, and asked them to make estimates and forecasts of complex political and economic questions. Some of those questions included whether there would be a violent overthrow of apartheid in South Africa, what the oil price would be in five years time or whether Apple's share price would go above a certain level by the close of the year. He then tracked how accurate the predictions were over the next 20 years. It was the most comprehensive study of expert judgment in scientific literature. He found that most of the experts were no better than "a dart-throwing chimpanzee"[xxxviii] at forecasting the future.

The same rule applies to many consultants and those planning early stages of major projects. It is likely the case that many major infrastructure projects are simply incorrectly forecasting what will happen in the future from the beginning. This can lead to projects starting off on the wrong foot right from the start. As one experienced infrastructure executive we interviewed put it, *"cost consultants often have little actual experience in project delivery, but they whisper in the client's ear that projects can be delivered quicker and faster than in reality is possible. This then encourages an adversarial tender process of bidders racing to the bottom, giving clients a false economy as prices inevitably rise and programmes run late."*

Why are we so bad at predicting the future?

Despite the importance of meeting deadlines and correctly estimating costs, industry statistics suggest that many project-based organisations greatly struggle. For example, studies in the construction, healthcare, aerospace, and information technology industries have found that anywhere from 33% to 88% of projects are delivered late and over budget.[xxxix]

As the UK's National Audit Office says, *"project failure in value for money terms is often built in when a project is initiated…we have observed that government is often too quick to arrive at a preferred solution, rejecting alternatives that may prove better value. Teams can also be under pressure from ministers or others to make early commitments about what a project will cost."*

Predicting the future is hard, especially when we are talking about projects to be delivered decades into the future. But there are certain quirks in human psychology that everybody working on major projects should be aware of and take into account:

1. Optimism bias
People tend to be overly optimistic when predicting how future events will unfold. Research has found, for example, that when asked, a typical homeowner expected home improvement projects to cost about $19,000 even though they knew the actual average cost of improvements across the USA was $39,000.[xl] Large projects are susceptible to exactly these tendencies. As the Department for Transport and Regional Economics in Australia says: *"Optimism bias extends to the whole suite of techniques used to assess projects — Cost Benefit Analysis, financial analysis, and assessments of environmental, regional economic, and macro-economic impacts."*[xli]

2. Planning fallacy
In 1979, Nobel Prize winner Daniel Kahneman and his research partner Amos Tversky wrote a breakthrough paper on how astonishingly bad human beings are at estimating how long tasks will take even when they have experience or knowledge of other similar tasks. For example, when a group of psychology students were asked how long it would take for them to complete a thesis, they estimated 33.9 days, and, when asked to consider unforeseen events causing very bad delays, they predicted 48.6 days on average. The actual average completion time was 55.5 days, outside even their worst predictions of the future. This phenomenon also exists when groups are asked to predict how long things will take.[xlii]

3. Larger team fallacy
Traditional economic thinking says that in general the larger an organisation gets the more efficient it becomes due to economies of scale. However growing larger also has more recently discovered

downsides, especially when large project teams are concerned. Although increasing a team's size provides the potential for many benefits (for example increased specialisation and wider range of perspectives), productivity may actually suffer due to the increasing challenge of coordination, communication and team members being allowed to coast below the radar and become demotivated.[xliii] Also as systems become larger and larger understanding them and the consequences or potential elements of failure can exceed the human ability to comprehend them.[xliv] Projects often fail to take this into account.

4. Social herding and the inside view

When problems become so complex or the information to assess a problem is hard to understand or pull together it may be sensible to look to the behaviour of others to help us make a decision. This can work out well most of the time, for example, seeking out the most popular TV on Amazon or Alibaba is probably not going to be a terrible decision. However in more complex decisions this fails. If everyone else is doing or saying the same thing 'groupthink' can take hold and people overlook fundamental and sometimes inconvenient issues. 'If six out of seven people agree with me, I must be right!' This is linked to what Daniel Kahneman calls the inside view, which is the tendency of people to ignore relevant data and information in the belief 'that this case is different and unique'.

For example we know that on average road projects go 20% over budget, but 'our project is not going to make those same mistakes, we are different, better, cleverer' even though the data and law of averages says otherwise.

If we didn't fudge the numbers projects would never get off the ground

"There is often an immense pressure on publicly funded projects to agree to a number and a deadline far ahead of work being complete that would give a reasonable level of confidence. Often political masters are also under pressure to force delivery and estimates of time for short-term advantage and are never there when issues inevitably appear."
Lord Paul Deighton, Sponsor Board for Restoration and Renewal of UK Parliament, Chairman of Heathrow Airport.

Most major infrastructure projects have a political master who personally wants the scheme to go ahead. But because the scheme is being planned under political and media scrutiny, there is almost always pressure for precise, up-front assessments of cost and delivery time that can often, in practice, be unrealistic and can be counterproductive to ultimate success.

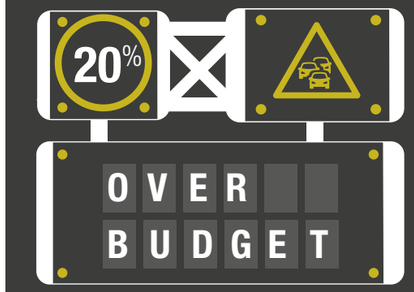
To progress projects from an initial concept you normally need to get some sort of sign-off which usually involves clearing some sort of hurdle rate, benefit cost analysis or achieving a benefit cost ratio above a certain number. These are highly sensitive calculations, where changing a small variable

A typical homeowner expected home improvement projects to cost about...

$19k

even though they knew that the actual average cost was $39k[xl]

On average, road projects go...



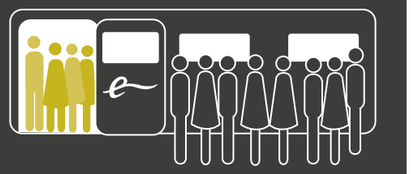
It took more than...

20 years

for the New Little Belt bridge in Denmark to achieve the traffic levels expected on day one[xlvii]

The number of people using Eurostar rail link between France and the UK today are only a...

third



...of the number projected in 1995[xlvi]

or assumption can produce quite dramatic improvements in the benefits of the scheme.
With projects teams (and some politicians with short terms of office) clearly having a vested interest in their project being approved they *"are willing them forward to get approval and produce the 'right' numbers"* in the words of one experienced project director we interviewed. This means that proponents of schemes may deliberately provide overly optimistic assessments of cost and time to win political approval for projects.[xlv] As Amyas Morse, the Comptroller General of the UK's National Audit Office (a similar role to the Inspector General in the USA or the Auditor-General in Australia) recently said: *"Analysts have expressed concern that they are under pressure to provide supportive rather than realistic forecasts."*

Sometimes organisations go even further and simply cut out any process of assessment all together. The US Department of Transportation said in 2018 that *"the Federal Aviation Administration frequently funded projects prior to approving their final scopes and budgets."*

There are very many examples from around the world of incorrect forecasts being made, but it is worth mentioning a few notorious examples for illustration:

- Compared to the forecasts made when planning the scheme, the number of people using the Eurostar rail link between France and the UK today are only a third of the number projected in 1995;[xlvi]
- It took more than 20 years for the New Little Belt bridge in Denmark to achieve the traffic levels expected on day one;[xlvii]
- In New Zealand, contrary to the project modelling, the new NZ$630m Kapiti Expressway between Mackays and Peka Peka actually made journey times longer; and
- In the UK, the cost of Network Rail's Thameslink Upgrade Programme cost rose by 18.0% from the start of the project.[xlviii]

The idea that project promoters may need to be slightly creative with their numbers to get them off the ground, knowing in reality that the numbers are very optimistic but it is for the 'greater good' is called the Hiding Hand theory.[xlix] In the words of the former Mayor of San Francisco, Willie Brown *"if people knew the real cost from the start, nothing would ever be approved".*

This kind of thinking, however, has significant problems and isn't a sustainable way of proceeding. As Prof. Cass Sunstein and Prof. Bent Flyvbjerg argue, this leads to two problems in particular: *"First, the project may be started despite the fact it is not financially and economically viable. Second, it may be started instead of another project that would have shown itself to yield higher returns than the project started, had the real costs and benefits of both projects been known. Both cases result in the misallocation of resources and, for public projects, waste of taxpayers' money. Thus for reasons of economic efficiency alone the argument [of the Hiding Hand] must be rejected".*

How do we solve this systematic problem?

With so many forces vested interests, improving forecasting accuracy is difficult – but not impossible. The previously mentioned Prof. Philip Tetlock of the Wharton Business School in the USA developed an approach that dramatically improved the accuracy of predictions. The performance of his 'Superforecasters' was about 30% better than the average for the intelligence analyst team who could read and use secret data while trying to predict the very same things (see case study).

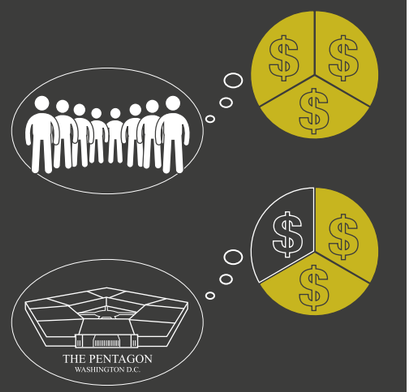
The elements of his research that can transfer to major projects are:

- **Triage the problem:** most energy, focus and challenge should be spent on the elements of the project that are new, most complex or dependent on others. The other parts that are more 'business as usual' are less likely to cause issues.
- **Use other project data and avoid the 'inside view':** in reality, nothing is 100% new; most things have been done in some way before. Look at the catalogue of examples around the world of similar projects to help shape your estimates and resist discounting them because your project is 'unique'.
- **Prediction is an iterative process:** estimates of cost and programme need to be constantly reassessed and updated as new information comes to light and detail becomes clearer.
- **Use the wisdom of crowds:** as Prof. Tetlock has shown, crowds of people are generally more accurate at prediction than smaller teams of 'experts'. Where possible can projects draw on this 'wisdom' for inputs into their projections? For example material price inflation estimates.
- **Challenge your thinking:** for the restoration and renewal of the UK's House of Parliament and the Hong Kong Airport project, 'heavy-weight' panels of experienced industry leaders from the private sector with the practical experience of major project delivery were set up whose sole purpose was to rigorously challenge what was being produced by the project or programme. Other large projects and governments should consider setting up these types of panels with the teeth to get the information they need to scrutinise large projects. This should not be feared by project sponsors but be welcomed as a way to improve and check their initial thinking.

Superforecasters performance was about...

30%

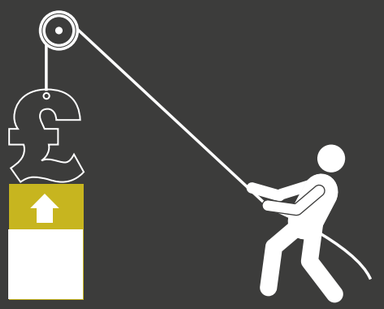
better than the average intelligence analyst team, who could read and use secret information.



A report for the UK's Department for Transport by academics recommended a...

64%

optimism bias uplift in cost estimates in the earlier stages of projects[i]



A world-leading report commissioned by the UK's Department for Transport by a range of well-respected academics also provides assistance when trying to combat optimism bias.[i] After crunching the data from many large transport projects they recommended a 64% optimism bias uplift in cost estimates in the earlier stages of projects. As time goes on and scope, design and programme become more clearer this 'optimism bias' uplift can be reduced and eventually be turned into a project contingency based on a realistic risk assessment.

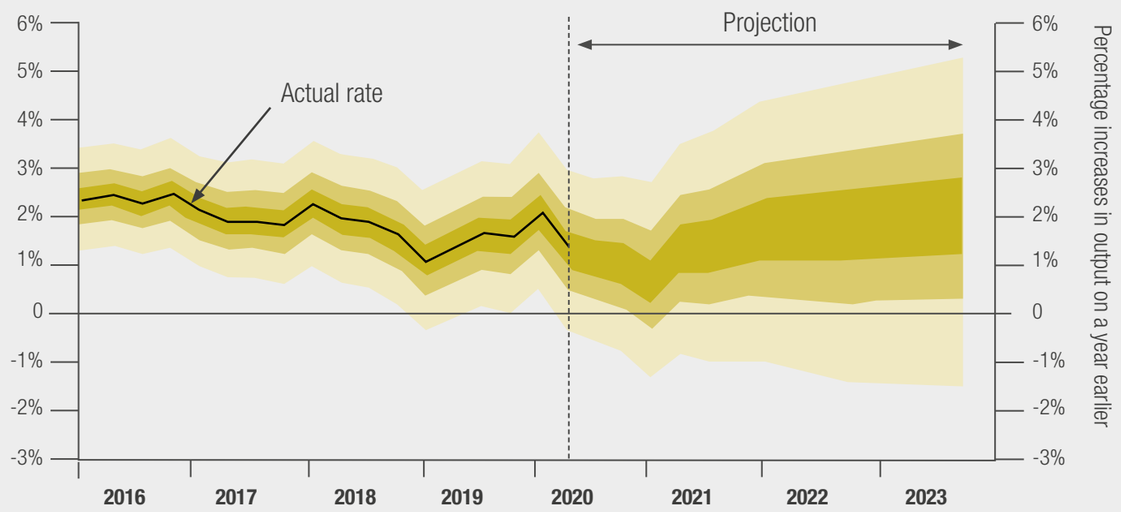
Politicians and infrastructure owners need to accept the complexity and difficulty in projecting costs and programmes decades into the future. They are looking for an unreasonable level of certainty in a very uncertain world.

In other sectors, politicians have accepted it is ridiculous to provide a level of certainty well into the future. For example, the OECD often projects future GDP growth of member economies using 'fan charts' with an increasing range of possible scenarios depending on how far into the future it is (see Figure 2).

The UK's National Audit Office also appreciates that this applies to large infrastructure projects stating that *"early cost estimates should be presented as a range, never a point estimate."*[ii] So why do so many large projects around the world commit to fixed point prices too early on in the project life?

In reality major projects are like an OECD fan chart but in reverse. At the start of a project, where the scope is uncertain, the cost range is quite wide and as time progresses things become clearer the range can tighten and prices become more certain. Projects and governments should consider taking this approach which is much more realistic about the complexities and uncertainties involved.

OECD growth rate projections for the UK Fig. 2



CASE STUDY: SUPERFORECASTERS

HOW YOU CAN IMPROVE THE ACCURACY OF YOUR PREDICTIONS

In the wake of the invasion of Iraq in 2003 and the very high-profile failure to find the weapons of mass destruction that the US intelligence agencies had said were 'certain' to be found, the Washington establishment knew that something had to change.

They decided to set up the Intelligence Advanced Research Projects Activity (IARPA) group based on the highly successful Defense Advanced Research Projects Agency (DARPA) which was created in the wake of Sputnik. IARPA reports directly to the US Director of National Intelligence and backs daring and cutting edge research that could make US intelligence better at what it does.

The United States has around 25,000 intelligence analysts and costs many billions of dollars. To test how effective these analysts were IARPA created a forecasting tournament in which various 'expert' teams would compete to make the most accurate forecasts. The questions posed ranged from how likely it was that Israel would sneak an attack on an Iranian nuclear facility to the future price of oil or whether the euro would fall below $1.20 in the next 12 months.

One of the teams taking part was created by Prof. Philip Tetlock of the Wharton Business School at the University of Pennsylvania. Instead of following a traditional approach (and those taken by the other entrants) of getting a small group of 'experts' together, he selected over 3,000 volunteers from the general public.

The volunteers had to get through some tough psychometric testing and were asked to follow a structured approach to decision making:

1. Split the problem into more manageable chunks and focus most of your efforts on the more complex and unknown elements.
2. Seek out evidence which goes against your views and pay attention to those who disagree with you.
3. Strike the right balance between 'inside' and 'outside' views.
4. When you make mistakes look for the errors behind those mistakes and be continuously open to learning.

Over time participants were given a 'Brier score' which is a measure of how accurate predictions are with reality. For example a score of 2.0 means your forecast is the opposite of reality, a score of 0.5 is what you would get at random and a score of 0 is when you are exactly right. Participants could see their score and how they ranked against other volunteers.

The average prediction of the 3,000 participants was taken, with the 40 best forecasters being given a slightly higher weighting. Then the results were 'extremised' to take into account the fact that people do not like to respond with '100%' certainty or '0%' certainty. This means that when you end up with an average prediction of something being 70% likely, for example, you would bump it up to, say, 85% in order to reduce the above effect. Prof. Tetlock and his team called this approach the Good Judgment Project (GJP).

Over four years, IARPA proposed around 500 questions for the different analyst teams to answer. To succeed, these teams had to beat an independent intelligence control group by 20% in year one, rising to 50% in year four.

Using this approach, GJP consistently outperformed the control group, winning the tournament every year. The Washington Post reported that 'a participant in the project' had told them that the Superforecasters performance was about 30% better than the average intelligence community analyst who could, of course, read secret intercept data not available to the general public.

Infrastructure projects are becoming larger, more complex and more integrated into a sophisticated system of existing infrastructure than ever before. In fact, over the last century major infrastructure project budgets have more than doubled in size in real terms.[lii]

It is no wonder that one of the challenges most large projects and programmes face is being able to understand their needs at different points in their life cycle and being able to effectively understand what on earth is happening at any one time. Many infrastructure owners and project teams are forced to define the 'end point' in order to gain approval and secure funding. However, often this is done without establishing a road map of the process they need to get there and the specific steps that need to be taken.

Taking 'control' doesn't mean layers of unnecessary bureaucracy or establishing a mature systems environment from day one. In fact it is more important to have the right principles and gateway reviews in place from day one, otherwise your system infrastructure could fail.

It is about setting the culture for standardisation, developing tangible and sensible processes that can evolve over time as your project data matures. A number of the individuals we interviewed thought that projects often 'produce reports for reports sake' which actually add little value and may actually confuse the situation. But consultants can sometimes feel the pressure to do this to prove their 'value'.

Large projects need an effective Programme Management Office (which could be part of an integrator) to help coordinate the many moving parts and provide relevant and useful insight into how the project is performing.

From Mace's experience and the interviews we conducted major projects to consider:

1. Take control early: setting the ground rules, integrated coding (work breakdown structure), templates and a well thought out intranet which systems can be integrated into are key. Importantly, this needs to be combined with clarity of project outcome and communicating how you intend to manage the works to prevent teams establishing their own ways of working and becoming siloed. Doing this also promotes effective collaboration.

2. Make your systems and processes specific to your project needs (and as simple as possible): each part of the project life cycle comes with specific requirements, and you need to understand each one. Avoid developing the full solution too early; systems are evolving and industry is changing – it is important to 'future proof' but establish a plan aligned to your gateway process which allows for maturing as the project develops.

3. Keep it simple: many projects have so much data and unnecessary reporting that it stops being meaningful and in fact may be damaging. For example, information overload is thought to decrease US productivity by at least $1 trillion a year.[liii] Establish the 'success criteria' at each significant stage towards your desired outcome. Then build your Programme Management Office environment around that criteria. Some people think that the more complex the project, the more data is needed. The reality is that by keeping the outcome and success criteria simple, the data produced can be higher quality and much more meaningful.

4. One version of the truth: do not duplicate tasks that the supply chain should be doing. It is vital that you set the structure that allows 'data to be inputted only once' and if that data is integrated from the supply chain then establish that framework within your contracts. Many projects duplicate schedule and cost data at project and programme level and in their supply chain, incurring unnecessary extra time and money.

5. Change happens: the needs of a project will change and this isn't just about managing change against a baseline, which is fundamental to any successful project. The ethos can change, such as funding, supply chain and scope. You need to be able to adapt your PMO. But if your outcome changes part way through, you are probably in for trouble.

Success is about having a project controls and programme management environment that allows teams to be empowered, undertake their day-to-day tasks in a systematic manner, and not overcomplicate things, while providing project leaders with the useful information and analysis to make good decisions.

We have laid out several fundamental problems with the way we deliver major projects around the world. According to our exclusive calculations for this report, unless we can improve how we deliver major infrastructure projects, taxpayers around the world will face an unexpected bill of around US$900bn and lose out on US$990bn in benefits.[liv]

That translates into a cost of cost of ₹10,820bn to India, S/.28bn to Peru, US$197bn to the USA and AUS$42bn to Australian taxpayers.[lv]

Throughout our report we have put forward suggested approaches that infrastructure owners and governments should consider.

Here we provide Mace's top 10 policy and practical suggestions:

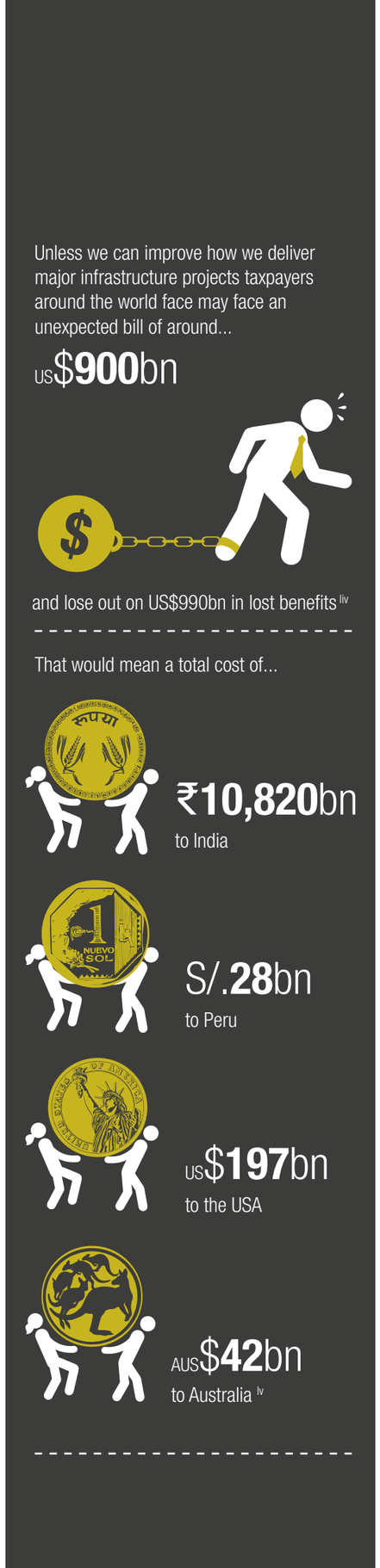
1. **Clear outcomes** – organisations and projects with a clearly and coherent stated outcome are much more likely to succeed. The best projects form part of an overarching strategy for a regional or national economy. A number of countries around the world have independent bodies to filter projects against national strategic objectives. For example, in South Africa the Presidential Infrastructure Coordinating Committee is focused on projects which, amongst other things, promote balanced economic development, address socio-economic needs, promote job creation and help integrate human settlements and economic development.[lvii]

2. **Tackle corruption -** unless corruption is routed out, the poorest in society will continue to suffer, quality of infrastructure will fall as funds are misappropriated and international companies who can bring in global best practice will be put off from working within local markets, which reduces competition.

   There needs to be transparency in the public contract process and award, conflicts of interest need to be managed and independent agencies should be brought into large, higher-risk projects and programmes from the start.

3. **Sensible procurement** – procure external organisations based on outcomes to better utilise the private sector's expertise. Infrastructure owners and governments also need to take a more constructive approach to trying to pass risk down the supply chain. In reality major risks always sit with the client but they pay for them twice when pushing them onto the supply chain. Contracts also need to be carefully thought through to ensure total alignment between the different parties involved and fair pain/gain and incentivisation measures.

4. **Improve your forecasting** – follow a Tetlock process for forecasting cost and programmes. Ensure you take into account optimism bias and planning fallacy. Provide forecasts to a range – not a point estimate – until you get enough clarity of scope and costs to move to a fixed point with contingency.



5. **Give consultants who forecast Brier scores** – the accuracy of predictions made by private organisations across the many public sector projects should be tracked. Over time it will be clear which organisations are most accurate and also provide them with a positive incentive to improve their predictions and not give in to undue pressure. After enough data is collected, a ranked table of organisations accuracy can then be shared right across the public sector and used in the procurement process.

6. **Create an independent scrutiny panel** – if your project or programme is large enough or you are a government agency with many large projects you should create a panel of industry 'heavyweights' outside normal public sector structures to challenge the project scope, timescales and costs. Their sole role should be rigorous challenge. This independent scrutiny panel needs to have the teeth and executive support to get the information they need for proper challenge. The London 2012 Olympics and the Hong Kong Aviation Authority both took this approach. Governments may choose to use this panel to challenge their top 10, 20 or 50 projects at regular intervals.

7. **Spend more money earlier** – many projects try and skimp on spending the necessary amount of money upfront to properly examine, scope and plan the scheme. By spending more money and time earlier, you to reduce the risks later on in the project, while giving more room for innovation.

8. **Quality over quantity** – remember that it is the quality of the people working on the project that make the difference. Find good people and empower them to get on with delivering the outcome. This includes finding consultants and supply chain partners with the right capabilities and appropriate delivery models that capitalise on that.

9. **Appropriate planning constraints** – if a major project needs to apply for planning now but will not be delivered for 15 years there needs to be enough flexibility in the planning to take account of evolving technology and societal trends. Governments around the world need to design their planning regimes with clear guidance around the level of detail which should be provided to receive approval, this will help combat the overly detailed development of schemes at a too early stage.

10. **Training academy for project 'sponsors' and leaders** – many large infrastructure owners are public bodies who can struggle to attract the right calibre of people to work for them due to pay constraints. In emerging markets in particular, people may also have limited experience working on large infrastructure projects. Hence it makes sense to provide high-quality practical training to current government employees to try and upskill them and enhance their skills. A particular focus should be given to the understanding of probability and risk and what that means to a project alongside how to hone in on a clear outcome for a project to achieve.

We hope that this report has stimulated new thoughts and possible approaches that you may take on current and future projects as well using the cumulative knowledge of our interviewees of the possible pitfalls to watch out for. We also hope that governments are receptive to our proposals and lead the charge in the areas over which they have influence.

APPENDIX 1– CALCULATIONS AND METHODOLOGY

Country	Amount spent on infrastructure per year (up to 2040, billions, USD, in 2015 prices) *	2030 spending level (billions, USD, adjusted for inflation)	Average cost implications of the overrun (billions, USD i.e. amount lost out on benefits)	Benefits reduced by (billions, USD)	Total cost to the economy (billions, USD)	Cost to the economy in local currency (billions)
USA	494	665	94.1	102.7	197	$197
India	186	513	72.6	79.3	152	₹ 10,820
United Kingdom	76	102	14.5	15.8	30	£23
Australia	71	96	13.5	14.8	28	$42
Canada	51	69	9.7	10.6	20	$27
Nigeria	37	135	19.1	20.8	40	₦14,420
Vietnam	25	41	5.8	6.4	12	283,120 ₫
South Africa	18	37	5.3	5.8	11	R161
Peru	17	28	4.0	4.3	8	S/ 28
Hong Kong	12.7	17	2.4	2.6	5	HK$39
Kenya	9	22	3.1	3.3	6	KES 644
New Zealand	7.5	10	1.4	1.6	3	$5
Singapore	3.9	5	0.6	0.7	1	$2
Globally	**USD 3,915**	**6465**	**915**	**998**	**1913**	**US$1913**

*Ref: Mace Calculations using the Global Infrastructure Outlook Report, Oxford Economics, 2017

Notes:

- Most countries use a benefit cost ratio (BCR) hurdle rate of 1:2, being conservative we are using a BCR of 1:1.5
- One year delay corresponds with 4.64% cost overrun (Ref: What You Should Know About Megaprojects and Why: An Overview, Prof. Bent Flyvbjerg, Chair of Major Programme Management, Said Business School, Oxford University, 2014)
- Average length of infrastructure project is 12.2 years (Ref: Institute for Government 2019 Whitehall Monitor)
- Average time overrun for large infrastructure projects is 25% (Ref: World Bank)
- Exchange rates calculations made using rates on the 30 January 2020
- Amount lost to the economy does not include the delay in realising benefits which would increase the loss even further.
- There is no indication of statistical interaction between geographical area and type of project. So we have assumed this is consistent across countries. (Ref: How common and how large are cost overruns in transport infrastructure projects?, Prof. Bent Flyvbjerg, Chair of Major Programme Management, Said Business School, Oxford University, 2003)
- The UK Treasury's Green Book recommends a 3.05% reduction in benefits per year of delay

APPENDIX 2 – INTERVIEW PARTICIPANTS

External

1. Miles Ashley, Founder of Wessex Advisory, former Transport for London Construction Director
2. Angela Barnicle, Chief Officer Asset Management & Regeneration, Leeds City Council
3. Jeremy Beeton CB, Chairman of WYG, former Director General of the UK Government Olympic Executive and Principal Vice President of Bechtel
4. Eamonn Boylan, Chief Executive of Manchester City Council and Director General of Transport for Greater Manchester
5. Paul Candelent, Project Director, Our Town Hall, Manchester City Council
6. Lord Paul Deighton, Chairman of Heathrow Airport, former UK Treasury Minister, former CEO of the London Olympic Delivery Authority and former COO of Goldman Sachs
7. Chris Evans, General Manager Construction & Facilities Management, Sydney Airport
8. Dale Evans, Chair of the ICE's Infrastructure Client Group, Alliance Operations Director at Anglian Water
9. Stuart Harvey, Major Projects Director, Transport for London
10. Sir Peter Hendy, Chairman of Network Rail, former Commissioner of Transport for London
11. David Leam, Executive Director of Infrastructure at London First, former Special Adviser to three UK Secretary of States for Transport
12. Andy Mitchell, Chief Executive of Thames Tideway Tunnel, formerly Programme Director of Crossrail Ltd
13. Kumaran Nagiah, Senior Advisor to the Director of Major Projects, Transport for London
14. Lord Jim O'Neill, Vice-Chairman of the Northern Powerhouse Partnership, Chairman of Chatham House, former UK Treasury Minister and Chairman of Goldman Sachs Asset Management
15. Shaun Pidcock, Programme Director - Smart Motorways, Highways England
16. Tom Samson, former Chief Executive of NuGeneration Limited, former COO of Emirates Nuclear Energy Corporation
17. Chris Walker, former economist UK Department for Communities and Local Government and HM Treasury
18. Barry White, Chief Executive, Transport for the North
19. Tim Wood, Director of Northern Powerhouse Rail, Transport for the North
20. Dr Sean Worth, former Number 10 Special Advisor, Head of the Conservative Party Research Department
21. Carlos Alberto Neuhaus Tudela, Executive Director of the 2019 Pan and Parapan American Games, Lima, Peru
22. Anuj Puri, Chairman, Anarock Group, India
23. Tony Chisnall, Director of Schiphol Airport's Capital Programme
24. Gabriel Daly, General Director of Private Investment, Ministry of Economy and Finance, Peru
25. Bernardo Gogna, Chief Development Officer at Los Angeles World Airports, USA

Internal

1. Nick Brand, Regional Director, Asia Pacific, Mace
2. Rob Ewen, Director, Mace
3. Colin Harvey, Director for the North and Scotland, Mace
4. Ian Galloway, Director, Mace
5. Ian Goddard, Project Director, Mace
6. Matt Gough, Director of Innovation, Mace
7. Dennis Hone CBE, Group Finance Director, Mace
8. Zoe Madams, PMO Services Director, Mace
9. Pawan Maini, Country Manager - India, Mace
10. Sharon Marsh, Head of Business Development, GP&I, Mace
11. Jason Millett, CEO for Consultancy, Mace
12. Jeremy Oakes, Country Manager - Australia, Mace
13. Mike Reader, Head of Strategic Pursuits, GP&I, Mace
14. Mark Reynolds, Group Chief Executive, Mace
15. Andy Sharples, Director for Energy, Utilities and Defence

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