The Economist Intelligence Unit

A report from the Economist Intelligence Unit

The impact of ageing infrastructure in process manufacturing industries

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About the research

The impact of ageing infrastructure in process manufacturing industries is an Economist Intelligence Unit (EIU) report sponsored by Oracle. It is based on a survey, conducted in September 2013, of 366 global executives in the oil and gas, utilities, chemicals and natural resource industries. Half of respondents are C-level executives or board members; the rest are vice-presidents, directors or business unit or department heads. Respondents are based in the Asia-Pacific region, Western Europe and North America (roughly 30% each), with the balance in Latin America, the Middle East and Africa, and Eastern Europe. More than half (55%) of the companies represented in the sample earn $500m or more in annual global revenue; 22% report more than $5bn.

To complement the survey findings, the EIU conducted in-depth interviews with industry experts and senior executives in these industries.

We would like to thank all survey respondents and the following executives (listed alphabetically) for their time and insights:

Theo Bergers, chief operating officer, Oranje-Nassau Energie BV

Cheryl Campbell, vice-president, gas distribution, Xcel Energy

Kevin Dunn, director of engineering, Missouri American Water

Gerald Galloway, professor of engineering, University of Maryland

Philipp Gerbert, senior partner, The Boston Consulting Group

Ronald Lee, global leader, asset care and responsibility, DuPont

Curt Pohl, vice president, distribution, NorthWestern Energy

Sath Rao, global vice-president of industrial automation and process control, emerging market innovation, Frost & Sullivan

Liane Smith, managing director, Wood Group Intetech

Executive summary

Process manufacturing companies in the oil and gas, utilities, chemicals and natural resource industries rely on proprietary infrastructure to run their operations. Much of this infrastructure is rapidly ageing, thus increasing the risk of failure. Subsequent disruptions hamstring operations and impede opportunities for growth, with the impact of these interruptions felt worldwide. As a result, executives in these industries must make tough decisions about where, when and how much to invest in infrastructure upgrades.

To control the rising costs and risks related to their infrastructure, many executives advocate a proactive approach to infrastructure upgrades and investment in innovative technologies as the best way forward. Such approaches, they say, will help them get ahead of breakdowns, improve safety and manage their resources more effectively.

This paper, based on a survey of more than 350 global executives in the oil and gas, utilities, chemicals and natural resource industries, explores how ageing infrastructure has affected operations in those sectors and the strategies executives are employing to overcome problems.

The research examines:

- the business implications of infrastructure failures;
- key factors executives consider when weighing infrastructure-upgrade decisions; and
- tools and strategies companies plan to use to rein in costs and mitigate risk in the years ahead.

Key findings include:

- **Ageing infrastructure is a headache for many industries.** A substantial majority (87%) of executives report that ageing infrastructure has had an impact on their operations in recent years; one in ten say problems related to ageing infrastructure have caused severe problems in their operations that they are still trying to address successfully.

- **The current infrastructure upgrade spend will rise.** Almost 33% of executives say they plan to increase spending on infrastructure in the coming years, while just 8% plan to decrease spending.

- **Fully 17% of executives say their companies will spend more than 40% of their operating budget on projects involving ageing infrastructure in the coming five years.** That is more than double the percentage of executives who say their companies spent that much of their budget on these projects five years ago.

- **New technologies that can identify problems before breakdowns occur are a top priority.** Technology will help organisations achieve greater efficiencies, extend the life of assets, reduce the risk of infrastructure failure and improve the ability to meet customer expectations and demands.

- **Higher levels of future investment correlate with greater perceived expertise**. Executives at firms which are expected to spend the largest portion of their operating budgets on these projects in the future are twice as likely to say that their organisations are more effective at infrastructure maintenance than their peers that are expected to spend the least. This higher-spending group is also the most interested in innovative technologies. Those spending the least are more focused on decreasing the risk of failure.
- **Poor project planning, regulatory interference and a lack of resources are the biggest obstacles to meeting schedule and budget goals. Better project management tools and practices may be a solution**. Better upfront planning is the top strategy for overcoming obstacles and delivering projects on time and on budget in the next five years.

As opportunities emerge, companies may become more proactive in their infrastructure upgrade endeavours. Their perceptions of adequate infrastructure maintenance may shift from repairing (stopgap) to upgrading (growth enabler) infrastructure. ■

Introduction

Companies in the oil and gas, utilities, chemicals and natural resource industries are facing an infrastructure crisis. Reliant on proprietary structures such as refineries, plants, oil rigs and mines, as well as power, water and gas networks to run their operations, these industries, in many cases, are working with decades-old structures that are beginning to break down.

Across the US, Europe and the Asia-Pacific region, critical infrastructure assets in these industries are already beyond their expected life span. In developed nations, breakdowns stem from decades-old systems that, even as they were built were using outdated technology and were designed and installed by planners who could not have foreseen the increased demand. In developing nations, a lack of infrastructure project oversight and expertise, compounded by insufficient funding and soaring populations, are pushing already fragile systems beyond their limits.

Governments are paying attention. A 2013 US Department of Energy report warned that the nation's entire energy system, including networks to deliver fossil, nuclear and existing and emerging renewable energy sources, is vulnerable. The outlook is equally grim around the world. Statistics indicate that, globally, approximately 53GW of power-generation capacity (of which 37GW are in Asia) will cross the 40-year mark by 2015. Power plants have an anticipated useful life of approximately 25-35 years.

Kevin Dunn, director of engineering for Missouri American Water, in St. Louis, Missouri, is in the midst of his own utility's ageing infrastructure challenge. "Some of our system was designed 100 years ago, with pipes that are too small to meet today's standards," he says. His team has aggressively replaced and upgraded the company's 4,200 miles (6,760 km) of water pipe infrastructure in recent years to prevent outages and to maintain operations. But it is a constant battle. "There is always a bigger need than the funds available," he says.

Companies across these process manufacturing industries are experiencing similar issues. Nearly all (87%) of the executives surveyed for this research say ageing infrastructure has had some impact on their operations in the past 3-5 years. More than one in ten report that these issues have resulted in severe consequences that they are still trying to fix. ■

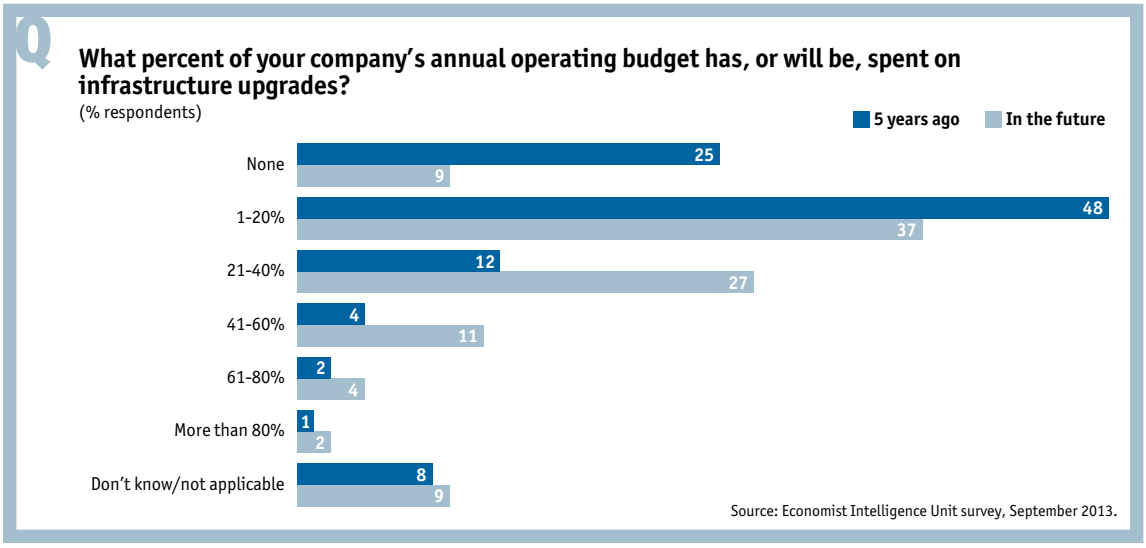
1 Risk and efficiency drive investment

Many organisations in process manufacturing industries push their infrastructure past its intended life span as a way to delay major investment and wring more operational value from these assets. This short-term approach, which requires increased vigilance and more frequent maintenance and repairs, heightens the risk of system failure.

According to the American Society of Civil Engineers (ASCE), an estimated 240,000 water-main breaks per year occur in the US. Ageing power generation equipment brings similar headaches. Significant power outages more than tripled to 307 in 2011 from 76 in 2007, according to the "ASCE 2013 Report Card for America's Infrastructure". Reliability issues are also emerging because of the complex process of retiring older infrastructure. Such uncertainty of reliability increases vulnerability to cyber attacks.

In the oil and gas industry, roughly half of all major maintenance projects in mature oil fields are caused by ageing infrastructure. These lead to well-integrity problems, including scaling, corrosion and failed well equipment, according to Wood Group Intetech.

The frequency of such problems in ageing systems increases operational risk for companies and utilities, forcing them to invest more capital in infrastructure-upgrade projects to keep facilities running. According to the survey, more than three times as many respondents report that their companies will increase their infrastructure upgrade



investments within five years as those who indicated that their companies will reduce this spend.

Executives in the utilities industry foresee the biggest rise in spending—perhaps because the reputational harm from failure of their mission-critical power or water systems can take years to repair. Roughly 56% of executives polled in this industry say their organisations will spend 20% or more of their operational budgets on infrastructure upgrades in the next five years, up sharply from the 23% who say their organisations spent that portion five years ago.

Executives at companies that expect to spend a smaller portion of their budgets on infrastructure improvements focus on replacing infrastructure nearing the end of its life and lowering long-term operating costs. This suggests that they are more concerned about near-term risks. By contrast, executives at companies slated to spend more are seeking new technologies to improve efficiencies—indicative of a more long-term, strategic view.

Many executives also report a desire to implement more effective project-planning strategies and to become more proactive in their infrastructure upgrade endeavours. They are shifting their perception of infrastructure maintenance and upgrading from that of a stopgap measure to a growth enabler.

Liane Smith, managing director of Wood Group Intetech, a Chester, UK-based asset integrity consulting firm for the oil and gas industry, argues that such forward-looking investments make good long-term business sense. "The benefits of a proactive approach are all economic," Ms Smith says. "It's how you optimise your assets, so you can get the most value out of them over time." ■

2 Global disparities

The trigger for these rising costs vary globally, says Philipp Gerbert, a Munich-based senior partner at The Boston Consulting Group. "Ageing infrastructure is a problem in developed nations, while congestion due to hyper-growth is a problem faced by a lot of emerging countries," he says.

Many countries in Asia, for example, struggle with persistent power shortages arising from inefficient and unreliable systems. The most dramatic demonstration of this occurred in 2012, when a massive power outage in India paralysed cities and left more than half a million people in the dark for hours.

"There is notorious underinvestment in this region," Mr Gerbert says.

The huge population growth in many of these countries has exacerbated the demand problem—which is straining already overworked infrastructure systems, says Gerald Galloway, a professor of engineering in the Department of Civil and Environmental Engineering at the University of Maryland. "Beijing expects to add 600,000 people yearly," he says. "As populations grow, infrastructure problems explode."

These struggles are reflected in the survey data. Roughly 53% of executives in the Asia-Pacific region say risk to operations is a highly important part of their companies' investment decision-making process. This is well above the 33% of executives at North American firms who make the same claim.

Developed nations face more long-term problems. Their networks are operational, but they are long past their expected life span and must be upgraded to increase throughput, support new communication technologies and lower their environmental footprint.

"The US has one of the oldest power generation systems in the world. While these plants and networks still function, they require constant maintenance to avoid outages and are often inefficient and highly polluting," Mr Gerbert says. "By contrast, Germany has invested heavily and consistently since WW II. But it faces many new requirements in its nuclear exit and transition towards the goal of an 80% renewable share by 2050. This raises huge upgrade challenges."

Many nations also rely on ageing coal plants and refineries, which are relatively cheap to run but generate substantial CO2 emissions. The cost-benefit calculation for operating these plants today is still strong, he says. But governments enacting tighter rules around air quality will likely force companies to ramp up investment in greener infrastructure alternatives. "Once environmental regulations start taxing CO2, they will have to build new, cleaner plants," he says. ■

3 The infrastructure conundrum—short-term fix or long-term strategy?

With limited budgets, and rising pressure from customers and regulators to meet sustainability and reliability goals, these businesses face tough decisions about which infrastructure upgrade projects to support. When problems are identified, stakeholders must decide whether to make small, lower-cost repairs to eke more time from failing assets, or to make major investments in upgrades that require far more time and capital but will last longer and support future expansion goals.

"There is always pressure to make short-term, small-cap decisions," Ms Smith says. "But it often

CASE STUDY Making the case for an infrastructure upgrade

How NorthWestern Energy used assessment tools to support investment decisions

When the operations team at NorthWestern Energy review the reliability of the organisation's infrastructure, they must take the long view. Because the utility's infrastructure is so vast, and upgrade projects can take years, the team must consider the viability of the power network five years out—or further.

In the last review of reliability four years ago, the company faced a problem. "We have a bubble of infrastructure that is 30-50 years old," says Curt Pohl, vice president of distribution operations. "The time to replace it was coming due."

Mr Pohl's team knew that to avoid outages the company needed to be more proactive about replacing the infrastructure before it failed. The solution was a seven-year, $350m infrastructure replacement project that would allow the utility to maintain high levels of reliability, coupled with smart-grid technology that it could further expand in the future.

Making the case for this major investment during an economic downturn wasn't easy. Not only did Mr Pohl's team have to sell the utility's leadership on the idea, it also had to convince regulators to support the project—and the related rate increase that would be passed on to customers.

Rather than force his own agenda, Mr Pohl provided regulators and executives with several investment scenarios. Options included reducing the current infrastructure spend to cut operating budget costs; maintaining the same level of spending and allowing his team to do repairs and maintenance but no additional upgrades; and increasing the level of investment to support his upgrade strategy.

With each scenario, Mr Pohl showed the impact to NorthWestern's System Average Interruption Duration Index (SAIDI), a common measure of reliability in the energy sector. Predictive analytics showed regulators and executives that maintaining or lowering investment levels would lead to higher levels of power disruption over time. After numbers were shared, executives were on board, he says.

Mr Pohl's team received support for the project, which was launched two years ago. By starting early and spreading the upgrade over seven years, the level of reliability will be maintained and the financial impact will be relatively small. "This project protects our system from degradation without overburdening customers", he explains, "so the cost-benefit analysis was high." ■

makes better business sense to spend more money on upgrades that will deliver a higher level of integrity for the long-term."

As companies consider their investment priorities, cost, not surprisingly, is top of mind. More than half (55%) of respondents see the financial impact of an ageing infrastructure as a highly important factor in such decisions. Notably, more of those outside the C-suite (60%) than in the C-suite (50%) are concerned about financial implications, perhaps because the former are closer to the front lines of the business and more accountable for budget decisions.

However, cost should not be the only factor considered, says Curt Pohl, vice president of distribution for NorthWestern Energy, a power utility in Butte, Montana, that serves Montana, South Dakota and Nebraska. "You have to balance cost against risk to reliability and performance," he says.

Striking the right balance requires effective project management tools and processes to ensure that thorough due diligence and risk assessment have been completed and that the project team has the necessary resources and leadership in place to deliver, he says. "A strong project management framework gives you the confidence to execute your plan successfully." ■

4 The price of failure

Convincing executives and regulators to make proactive investments in infrastructure can be challenging. But when companies fail to take such approach, they increase the likelihood of facing emergencies and the resultant high costs of repairing failed infrastructure.

"The cost of responding to a crisis is so much higher than a planned response," Ms Smith says. "When you are in crisis response, you pay a premium price for all activities."

Companies also risk a negative impact on their brands, which can affect current and future business, adds Theo Bergers, chief operating officer of Oranje-Nassau Energie, a Dutch oil exploration and production company headquartered in Amsterdam.

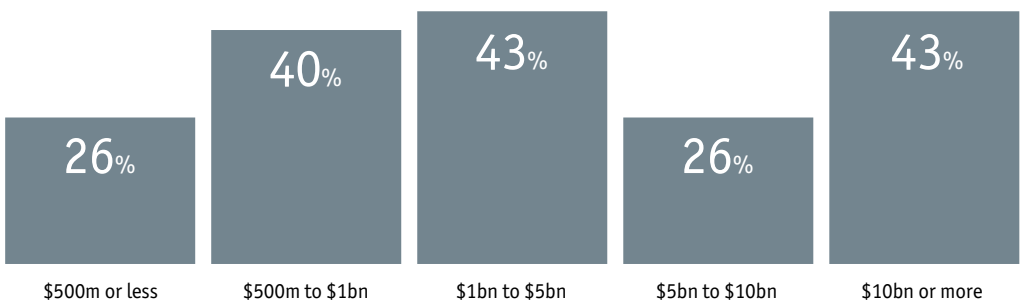
One need only consider recent incidents, such as the massive oil spill in the Gulf of Mexico, to know how disastrous a major breakdown can be.

"It takes years to build a reputation," Mr Bergers notes. "But one serious infrastructure failure can destroy it."

Perhaps that is why operational failure ranked first among concerns related to ageing infrastructure. Risk to operations is also cited as a top decision-making factor by many executives in these industries. According to the survey, 54% of those who will spend more than 20% of their budget on infrastructure upgrades in the future say risk to operations is highly influential in their decision-making process.

This is an even bigger issue in larger companies.

Q What are the biggest concerns your organisation has regarding the impact of ageing infrastructure on operations? **Risk of operational failure**
(% respondents)



Source: Economist Intelligence Unit survey, September 2013.

Roughly half (51%) of executives in firms that earn more than $1bn in revenues and 58% of those with $500m-to-$1bn in revenues say risk to operations is a highly important factor in the decision-making process, versus 36% of executives of businesses with $500m or less in revenues.

This focus on risk makes sense because failures can have a cascading effect on the business, says Ronald Lee, global leader of asset care and reliability at DuPont. It costs more to fix an infrastructure failure than to avoid it, he notes. But an operational shutdown because of these failures affects the company's ability to meet customer demand. That can lead to lost business, Mr Lee says. "It is a lot easier to maintain a customer than to lose one and win them back."

Access to human resources is also a primary decision-making factor for those spending more of their budget on infrastructure. Roughly 66% of those who expect to spend more than 20% of their budget on these projects in the future say access to human resources is moderately (46%) or highly (20%) important in the making of such decisions.

This issue is especially critical in the oil and gas industry, according to Oranje-Nassau Energie's Mr Bergers. His utility struggles to find experienced people to manage its infrastructure upgrade projects. Mr Bergers anticipates that the problem will only worsen in the coming years. "The old boys are retiring, which is creating a big generation gap in expertise," he says. "That's a major risk for us."

This lack of talent directly affects the cost of his infrastructure projects because the only way he can staff them is to lure experts away from competitors by offering more competitive remuneration. "Our human resource costs are a major part of the operating budget. But without that expertise, the risk to safety is even higher, so it's worth the investment," he says.

Many organisations in these industries face losing valuable expertise when key personnel retire or take positions in other companies. Capturing best practices as part of the project management process, as well as training and mentoring of junior staff by senior staff, can help reduce that risk.

Mr Bergers's company is currently hiring and training younger workers to help capture and retain its knowledge capital. ■

5 New technology will fuel growth

As executives in these industries consider the best way to avoid such risks, many firms are turning to innovative new technologies to help them identify risks, to improve efficiencies and to extend the life of their infrastructure.

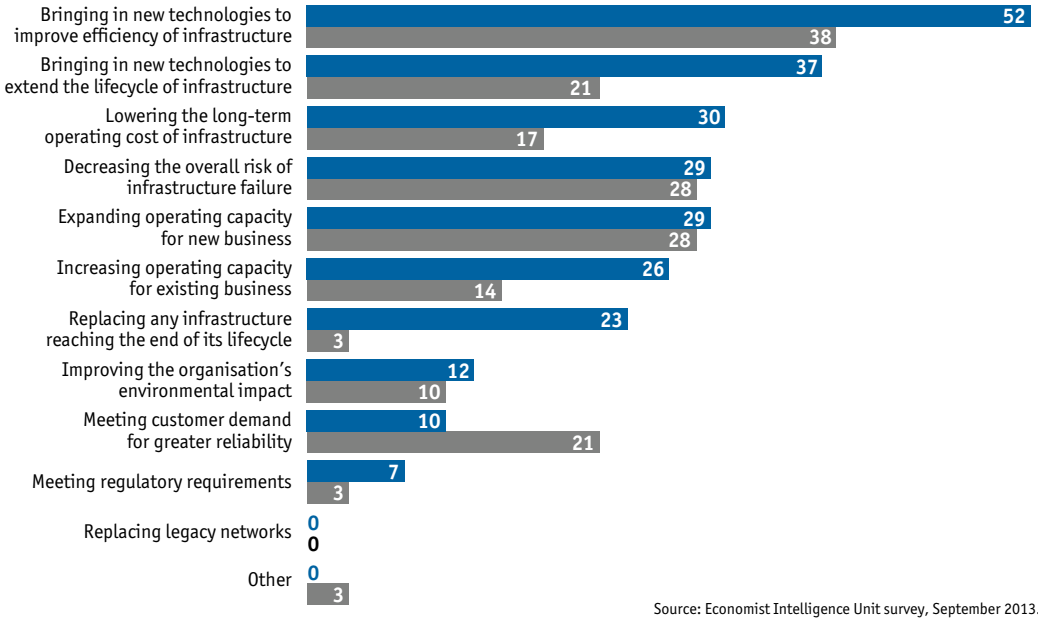
Many of these investments involve advanced asset integrity management systems and smart-meter technologies that integrate assessment tools and data management software to give operators real-time access to information about the state of their infrastructure and the potential for failures.

So, it is no surprise that, irrespective of an expected rise or fall in infrastructure spending, most respondents say their company's top

Q **If that percentage is expected to increase over the next five years, what will your infrastructure investment priorities be?**
(% respondents)

If that percentage is expected to decrease over the next five years, what will your infrastructure investment priorities be?
(% respondents)

Top priorities for organizations increasing or decreasing their infrastructure spend, as a percentage of the operating budget



Source: Economist Intelligence Unit survey, September 2013.

investment priority going forward is new technology to improve efficiencies. More than half (52%) of respondents who expect to increase their infrastructure spend proportionately, and 65% of those from organisations with revenues above $1bn, say technology to improve efficiencies is a top priority.

Technology is also viewed as an efficiency enabler among a broad swathe of executives. Between 52% and 66% of respondents at businesses with less than $1bn in revenues, and 50% of those with more than $10bn in revenues, say technology to improve infrastructure efficiency is a top-three priority. Another 44% say that they will seek new technologies to extend their infrastructure's life.

New technology is a higher priority for executives who expect spending to increase in the future, particularly among the biggest spenders. A sizeable 58% of respondents who say their firms will spend more than 40% of their budget on infrastructure upgrades five years from now also say that they will invest in technologies to improve efficiencies, versus just 13% of executives in organisations that expect to spend 20% or less on such projects. This suggests that executives who devote more resources proportionately to infrastructure upgrades place a higher value on innovation.

This technology focus also reflects the C-suite's broader strategic view of value and risk, says Sath Rao, global vice-president of industrial automation and process control, emerging market innovation, at Frost & Sullivan in Mountain View, California. "Managers see risk in terms of whether their piece of the plant is operational," he says. "But the C-suite's view of risk is focused on shareholder value, legislative requirements and internal compliance."

That broader perspective makes more robust project and programme management processes attractive to executives who want to gain significantly more information about where project resources are going, how effectively those projects are being run and how well these investments

CASE STUDY The right pipe at the right time

Missouri American Water uses new technology to lower its risks and better manage infrastructure investments

Missouri American Water manages 4,200 miles of water-main pipes, most of which are buried, across Missouri. Because the infrastructure is hidden, it is hard to determine its condition.

"It's pretty easy to figure out when a pump is going bad, because you can walk right up to it," says Kevin Dunn, director of engineering. "But we can't see or touch the pipeline, so it is difficult to decide when it should be replaced."

This challenge is now easier thanks to two new leak-detection technologies Dunn's team is piloting.

The first project involved using electromagnetic technology to test the viability of ten miles of a 36-inch prestressed concrete water main leaving the St. Louis County Central Plant. "A leak in a 36-inch main would cause a lot of damage," he notes, "So we want to be proactive in preventing that." The tool runs a sensor through the pipe to test the structural capability of the embedded prestressed wires. If the wires show signs of failure, leaks often follow.

Mr Dunn's team is also testing infrared technology that identifies temperature fluctuations while driving a specially equiped van. An Infrared camera finds changes in temperature below the street that helps indicate leak patterns and lets the team know which section of the pipe should be replaced.

While these technologies required some upfront investment, they saved Mr Dunn from making unnecessary replacements. Just one-tenth of the water main system showed problems.

"The key with this technology is to replace the right sections of pipe before they fail," he says. "It also means I can save the other nine miles of pipe-replacement cost and put that towards other projects," he adds. ■

support the strategic goals of the organisation.

It is also driving their interest in assessment and forecasting technologies that can act as early warning systems, offering clarity about when and where infrastructure failures are most likely to occur. This enables operations teams to get ahead of problems and helps executives better prioritise their infrastructure investments.

"The ability to do predictive modeling will help them stretch their dollars and mitigate risks in the future," Mr Rao explains.

The pay-off of such knowledge can be substantial, says DuPont's Mr Lee. "If we can detect a problem early on, it costs us ten times less to fix it than if we wait until it fails."

Such forward-looking companies achieve these savings because project teams can arrange shutdowns that minimally impact customers and operations. They also have the time to properly plan and staff the projects for efficient completion at lower costs.

This approach to managing infrastructure risks is also safer, says Cheryl Campbell, vice-president of gas engineering and operations for Xcel Energy in Denver, Colorado. In the last few years, her team has used pipeline in-line inspection tools originally developed for the oil and gas industry, including smart tools to detect damage in buried pipelines, so the company can avoid system failures.

"This technology tells us so much more about our assets," she says. "It's amazing what we can see."

Ms Campbell has already observed several instances where these tools detected hidden infrastructure anomalies that needed to be addressed, including a pipe that was close to breaking at the entrance to a residential subdivision.

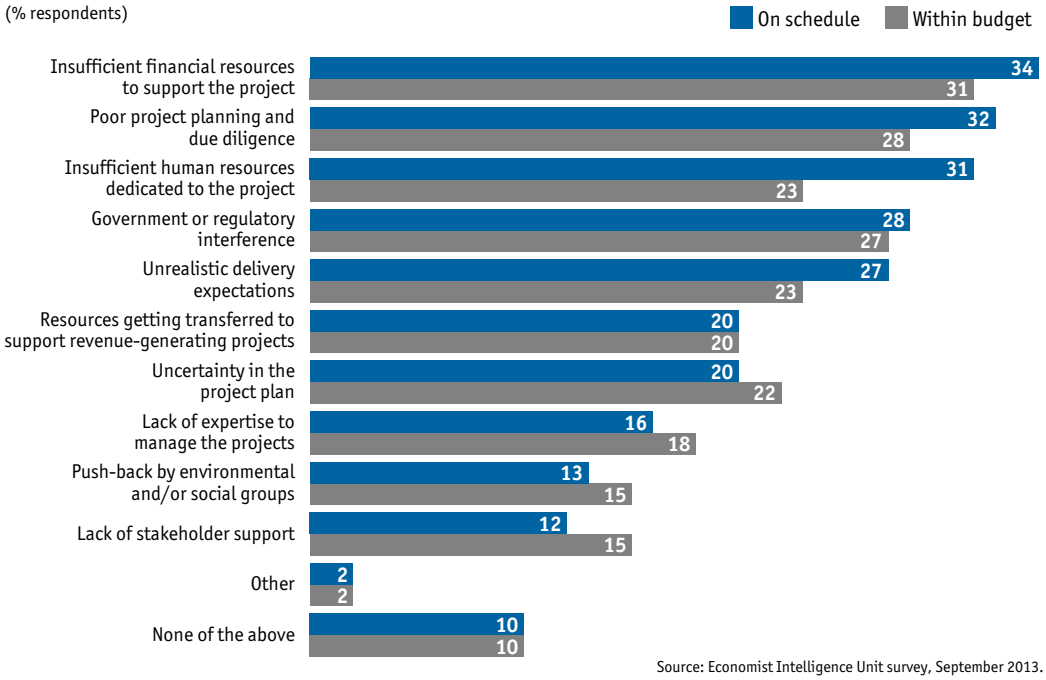
"The pipe was buried, so unless we dug a hole and checked it, we wouldn't have known there was a problem," she says. Thanks to the smart tool, her team was able to shut off gas flow to that area and make repairs before the pipe broke. "It was planned and well-thought-out event," she says. "And it was safer and much more cost-effective to solve than if a blowout had occurred." ■

6 Poor planning, limited resources and other obstacles

Stretched resources, rising regulatory demands and unpredictable economic cycles are challenging for companies in capital intensive industries when working to make long-term plans and commit substantial resources to infrastructure investments. Infrastructure replacement projects can cost hundreds of millions of dollars and take years to complete, thus any decisions about major upgrades can have a dramatic impact on budgets and operational plans. Perhaps that is why survey respondents cite insufficient financial and human resources, poor project planning and regulatory interference among their top obstacles to successfully delivering infrastructure upgrade projects.

Executives who cite the largest budget

Q **In your opinion, what are the biggest obstacles to delivering successful infrastructure upgrade projects in your organisation?**
Please select top three.
(% respondents)



Source: Economist Intelligence Unit survey, September 2013.

allocation for infrastructure upgrades also point to regulatory interference as a considerable obstacle to meeting budget goals. This group also ranks stakeholder involvement high on their list of strategies for overcoming obstacles, while executives at companies with smaller budget allocations consider this strategy to be less crucial to success. This suggests that high-cost, high-priority projects require active executive leadership to meet critical deadlines.

Regulatory issues are always front of mind at DuPont, says Mr Lee. "We view regulatory guidelines as the minimum essential requirement in asset management and make sure we are in compliance with 'right to operate' guidelines as our top priority."

Mr Lee's team keeps a close eye on regulatory requirements that impact DuPont's operations to ensure that the company's infrastructure remains compliant. However, guidelines often change, making it difficult to stay ahead of them. "We usually have insight into what's coming, but sometimes we need to play catch-up," he says. That can mean shifting resources from other asset-management areas into regulatory projects to ensure that critical deadlines aren't missed. ■

7 Better project management

Given these obstacles, it is no surprise that many organisations believe better early planning and more effective project management processes will help them overcome obstacles and meet budget and expansion goals. In a surprising show of alignment, executives in every sector, region and revenue range say better upfront planning is the best way to overcome obstacles to meeting infrastructure project deadlines. Better planning was also selected as a top strategy overall for meeting budget goals.

Executives at chemical and natural resources companies are particularly attuned to the need for better upfront planning. More than 70% of respondents in both industries cite it as their top strategy for meeting schedule goals.

The focus on better project planning makes perfect sense to DuPont's Mr Lee. "It's about looking at the entire life-cycle cost of the asset, from design to decommissioning," he says.

Organisations with strong project and programme management processes are better able to prioritise which projects to fund with limited resources and to identify any risks that could potentially derail those projects later.

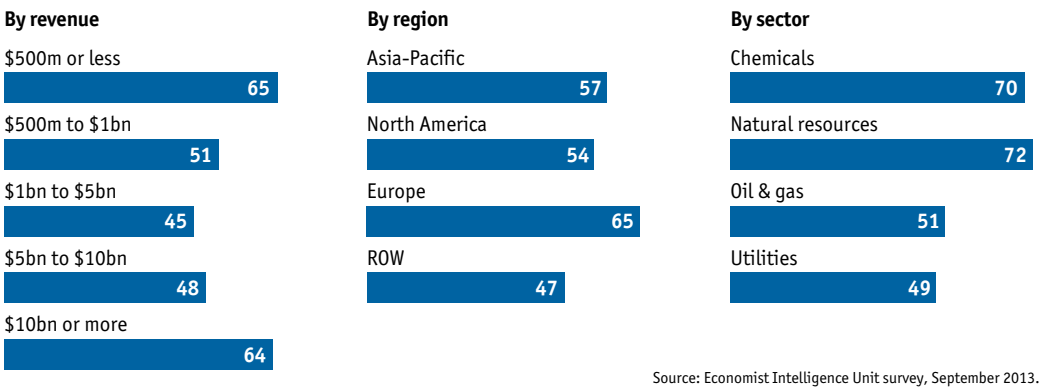
"You have to have good project planning," says Missouri American Water's Mr Dunn. "A comprehensive project planning strategy ensures

Q In your opinion, what would help you overcome these obstacles in the next five years to bring infrastructure upgrade projects in on time and on budget?

On schedule

(% respondents)

Better up front planning to define a realistic schedule for the project



Source: Economist Intelligence Unit survey, September 2013.

the right projects get funded and delivered."

Executives also see value in improving other aspects of their project management process. More than one in four say that more proactive risk management, ensuring that adequate resources are available to support projects, and securing increased stakeholder involvement would help them overcome obstacles to delivering projects. Among those who said their organisations planned to spend more than 40% of their budget on these projects five years from now, 43% noted increased stakeholder involvement high on their list of strategies to meet critical deadlines.

These are all attributes of a mature project management practice that focuses on managing and mitigating risk, optimising project plans, balancing resources and managing schedules across the portfolio of project investments.

At DuPont, the planning process for infrastructure upgrade projects focuses not only on what should be done today, but also on how to create efficiencies in the future. This ranges from designing and placing equipment for easy access for maintenance, to choosing technology that reduces energy costs, to considering the benefits of replacing rather than fixing infrastructure so that the company will be better able to expand capacity in the future.

"If we can make the infrastructure more effective for a longer time, it will generate a greater return on that investment," he says.

Better project planning and due diligence also eases interaction with regulators, says Xcel Energy's Ms Campbell. "If we can prove that we will achieve what we said we would achieve, they are a lot more likely to trust us," she says.

Achieving the benefits of strong project- and programme-management practices takes time, but it's worth it, Mr Lee says. DuPont has implemented several new project management tools and processes in recent years to better track the schedule, cost and quality of project outcomes; these have helped his group deliver better on-time, on-budget performance.

"We are seeing significant improvement," he says. Although he notes that the improvement process is far from complete: "We regularly look at what tools may be necessary and what the rest of the industry is doing to determine if we need to change our practices or some aspect of our performance." ■

CASE STUDY Radioactive risks

How Oranje-Nassau Energie uses proactive assessments to protect workers and cut time on upgrade projects

Much of the process related infrastructure on a deep-sea oil rig is below the water's surface. That makes it extremely difficult for operations teams to validate integrity or to work on system components.

This adds substantial safety and operational risk to maintenance and upgrade projects, says Theo Bergers, chief operating officer at Oranje-Nassau Energie (ONE), an oil exploration company in the Netherlands. Ten years ago, if Mr Bergers's teams were replacing water overboard pipe, they had no data about the condition of the assets, which put workers and the business at risk.

Mr Bergers points to a multiple-year project to replace an 80-meter pipe in the sea. "When we pulled it up and sent it to shore, we discovered that it was covered in low-purity heavy metals and low specific activity scale," he says.

These potentially toxic materials forced the team to shut down the project to get protective gear and equipment, and to organize permits to dispose of the polluted pipe. "These materials can be very low radioactive, but still need to be treated with respect," Mr Bergers says.

Today, ONE teams avoid such risks by using assessment technology to measure corrosive materials on underwater equipment as part of their due diligence. These assessments help teams determine what kinds of issues they face in the upgrade process and how materials need to be handled.

"This saves us time because we don't need to stop the project due to unexpected risks," Mr Bergers says. "And we protect our employees from exposure to these materials." ■

8 Why companies need to take a proactive approach

A safe and solid infrastructure helps sustain and fuel growth. One critical strategy for maintaining these vital systems is to proactively address problems that would otherwise result in operational failures that can be enormously expensive.

BP's Macondo blowout in the Gulf of Mexico cost the company $42.2bn. Smaller leaks, outages and breakdowns still have serious financial consequences for already tight operations budgets. A 2012 report from Sensus, a utility infrastructure company, shows that US water utility companies collectively spend an estimated $9.6bn every year responding to leaking pipes.

Getting ahead of such failures will lower costs and risks, says University of Maryland professor Mr Galloway. "When you deal with infrastructure maintenance proactively, not only do you take care of current problems, you get ahead of future problems," he says.

Executives in these industries recognise the value that such an approach can bring to their operations. They cite improved agility and increased safety for employees and customers among the top benefits of proactively addressing infrastructure issues.

DuPont's Mr Lee uses similar measures as part of his company's asset-risk grading system, which rates the reliability of infrastructure based on safety, environmental impact, financial issues, quality and impact on the customer. "We look at the probability of risk and the consequences of failure around these categories," Mr Lee says.

If the consequences of failure are low, his team may choose to run a piece of infrastructure until it no longer functions. If the consequences could affect safety, operations or other key measures of success, however, the company will proactively pursue upgrades. "The grading system helps us prioritise how to best spend our resources," Mr Lee says.

As the world globalises and markets mature in developed economies, the ability to seize opportunities abroad is also highly valued—and solid infrastructure serves as a strong foundation for expansion. Having reliable infrastructure helps these companies pursue expansion goals more confidently and gain a competitive advantage over their peers.

"We view ourselves as very competitive," says Mr Lee. "Proactively investing in new technologies and strong project management methods will help us continue to be competitive so that we can capture shareholder value and ensure customer satisfaction in the future," he says. ■

9 Making the case for preemptive upgrades

However, embracing a proactive approach to infrastructure upgrades is neither easy nor simple. Convincing executives to make preemptive investments, rather than waiting for problems to occur, requires more than just a bigger project budget and the latest technology. In most cases, meeting this challenge demands a radical change in the project management culture, with changes promoted and supported strongly by leadership.

"Unless you have support from the top level, such change won't take place," says Wood Group's Ms Smith.

Xcel has spent the last several years working to transition from a "wait till it breaks to fix it culture" to one where the company replaces assets before failures occur, says Ms. Campbell. "It's been a challenge and we still have work to do, but we are staying the course."

Not only has Ms Campbell had to convince her leadership team to increase infrastructure investments in the near term to get ahead of problems associated with ageing infrastructure, she has also had to win over frontline workers, who may be offended at the roll-out of new assessment tools. "They feel like I don't trust them even though they've taken care of these pipes for 30 years," she says.

However, after Ms Campbell identifies a few buried problems that the maintenance crew couldn't have foreseen without digging up the pipes, workers are usually convinced. "We quickly go from 'Why are you questioning my ability?' to 'When can we do more tests in my area?'" she notes.

Xcel is not alone. Most executives interviewed for this report say they are trying to encourage a culture of proactive infrastructure management because they recognise the value it can bring to their operations.

As DuPont's Mr Lee explains: "By being proactive and holistic, you can extract greater value from your assets, increase your uptime and improve your ability to meet customer demands." ■

10 Conclusion

Ageing infrastructure will continue to affect process-manufacturing industries for years to come. However, those impacts may be reduced by organisational investments in time and resources to solve problems. The best solutions involve a blend of technology, project planning and due diligence. Collectively, these elements help organisations identify and resolve problems before crises occur.

This proactive approach requires both a significant financial investment and a substantial culture change. Averting impending problems for cost-effective and safe repair before failures occur, rather than narrowly focusing on compliance, improves a company's ability to be agile, to seize new opportunities and to protect customers, employees, operations and the corporate image from the costly consequences of infrastructure failure.

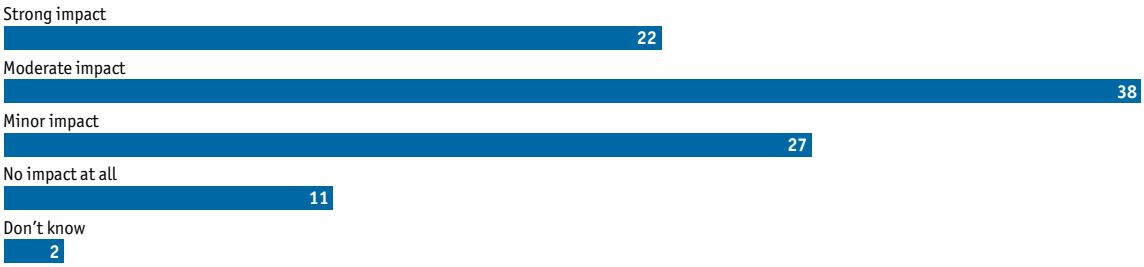
Survey results and in-depth interviews conducted for this research provide useful insights for organisations grappling with the rising cost of ageing infrastructure.

- **Implement strong project planning and due-diligence processes.** These management tools help companies improve their on-time and on-budget results, which lower operational risks and free resources for new investment opportunities. They can also help improve a company's working relationship with regulators.
- **Spend now to save later.** Making proactive infrastructure investments enables organisations to be more agile so they can take advantage of new business opportunities and avoid reliability issues. This also increases safety for workers and customers and helps companies gain a competitive advantage over their peers.
- **Invest in monitoring technologies and data analytics to identify infrastructure problems early.** These tools can help companies avoid the added expense of dealing with system failures and allow them to better identify where to invest limited project resources.
- **Change the project culture.** The only way to get ahead of failing infrastructure is to prioritise investments in upgrades and measure success by long-term value rather than short-term costs. To take hold, this culture change must come from the top and be championed by the C-suite. ■

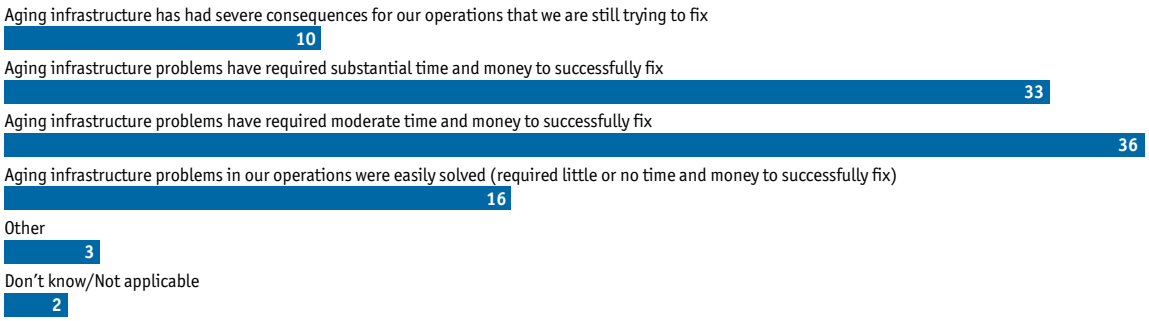
Appendix: survey results

Percentages may not add to 100% owing to rounding or the ability of respondents to choose multiple responses.

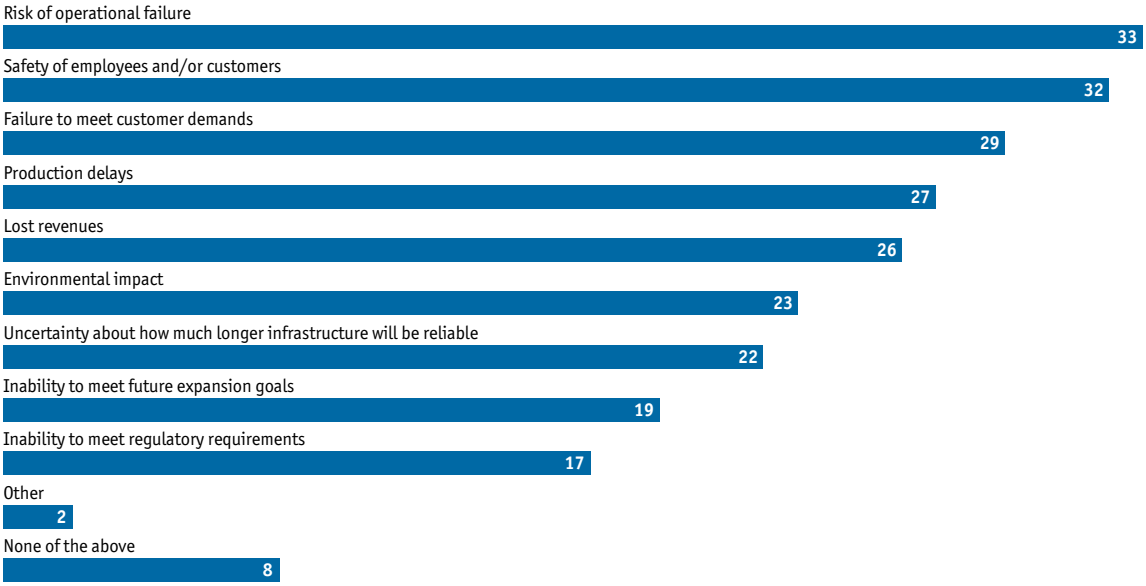
Which statement best describes how ageing infrastructure has affected operations in your organisation over the past 3-5 years?
(% respondents)



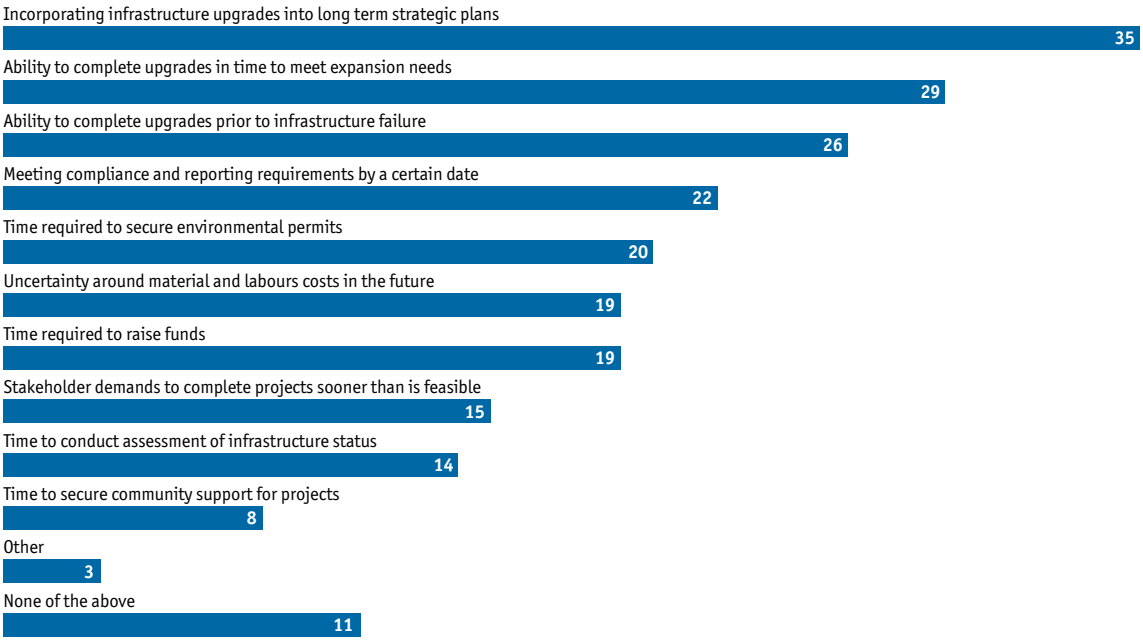
Which of the following best describes the main impact of ageing infrastructure on your organisation over the past 3-5 years?
(% respondents)



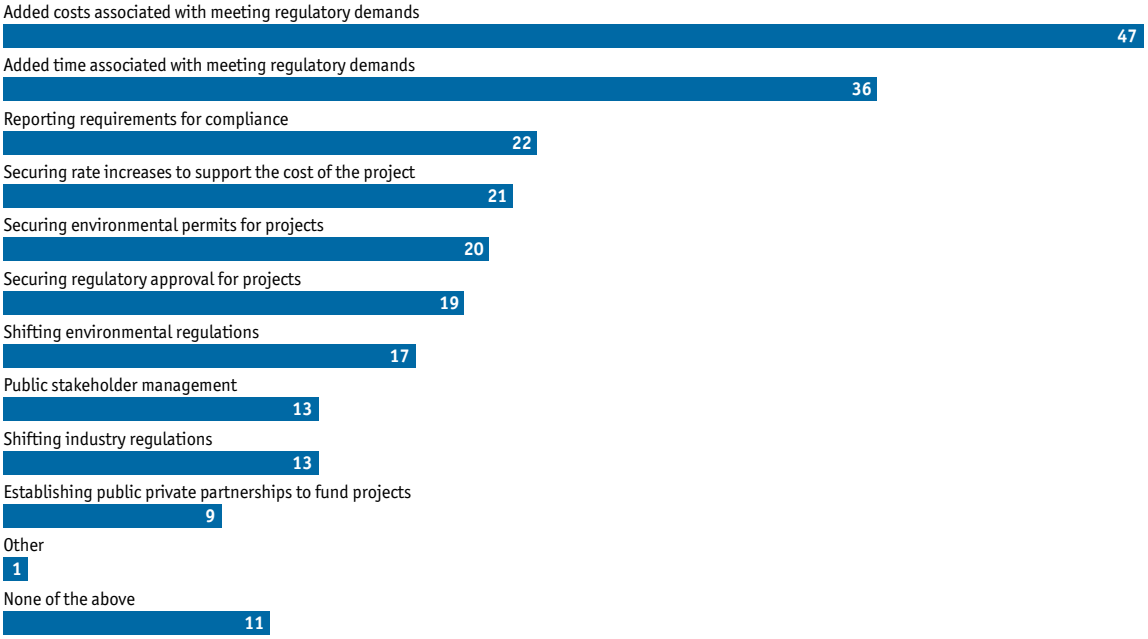
What are the biggest concerns your organisation has regarding the impact of ageing infrastructure on operations?
Please select top three.
(% respondents)



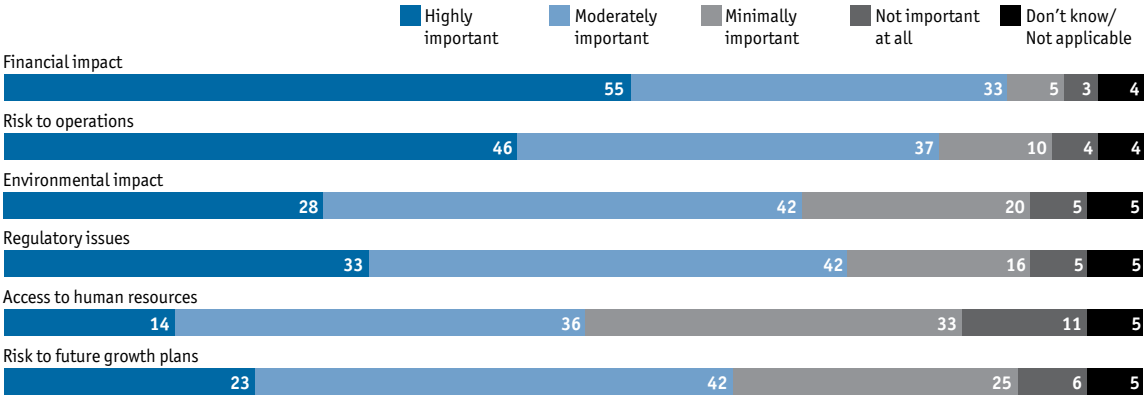
What are your company's biggest time concerns regarding the ability to upgrade ageing infrastructure in an efficient manner?
Please select top three.
(% respondents)



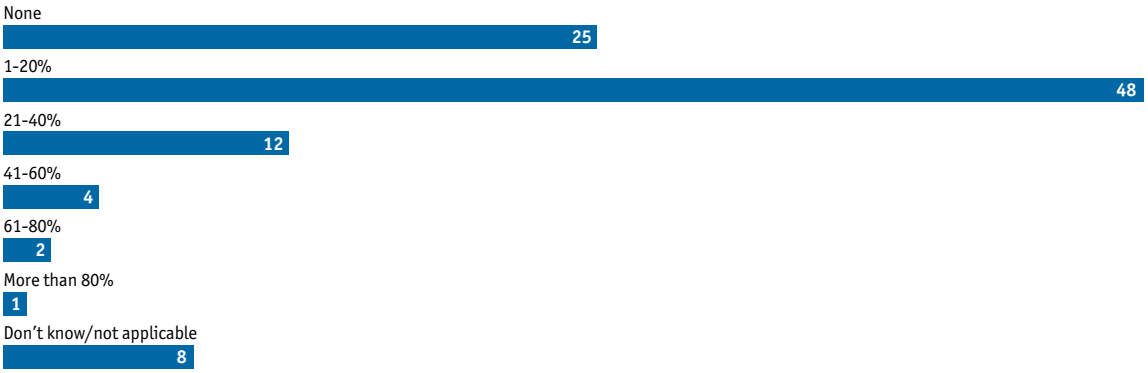
What are your company's biggest regulatory concerns regarding the ability to upgrade ageing infrastructure?
Please select top three.
(% respondents)



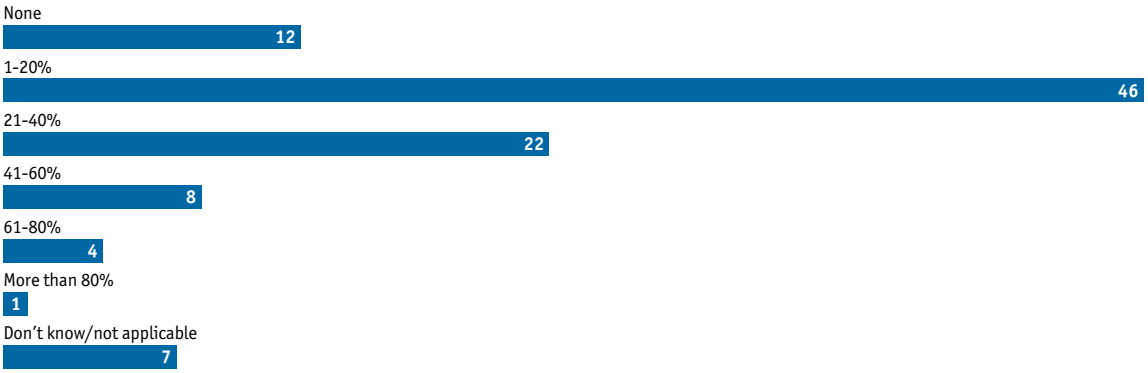
Which factors are most important in your organisation's infrastructure investment decision process?
Please select one response in each row on a scale from 'Highly important' to 'Not important at all'.
(% respondents)



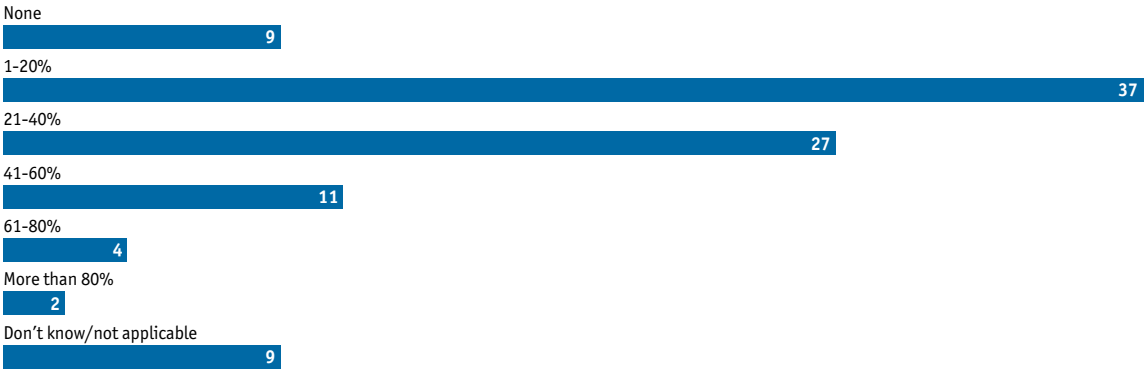
What percent of your company's annual operating budget was spent on infrastructure upgrades five years ago?
(% respondents)



What percent of your company's annual operating budget is currently spent on infrastructure upgrades?
(% respondents)

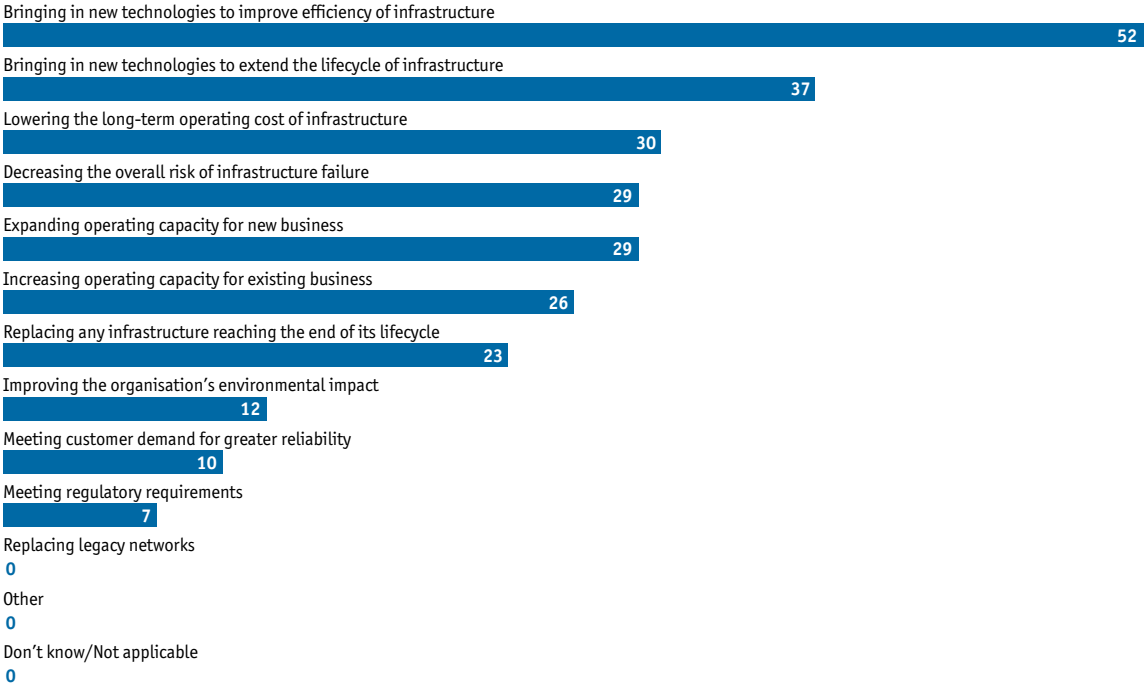


What percent of your company's annual operating budget will be spent on infrastructure upgrades in the future?
(% respondents)



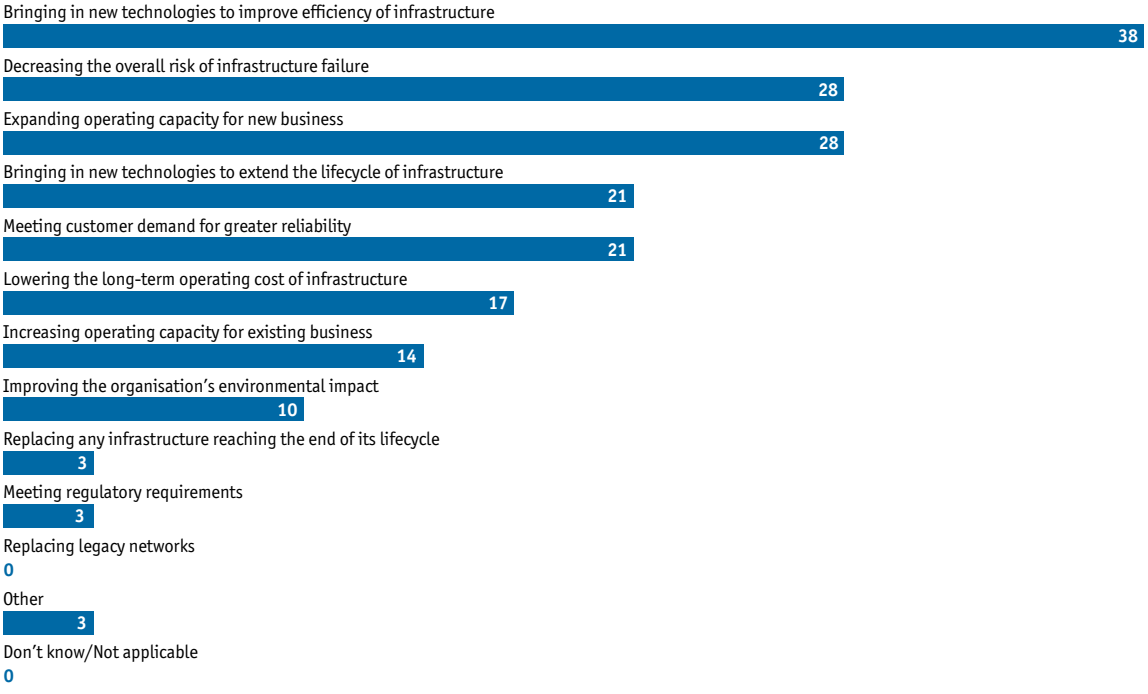
If that percentage is expected to increase over the next five years, what will your infrastructure investment priorities be?

Please select up to three.
(% respondents)



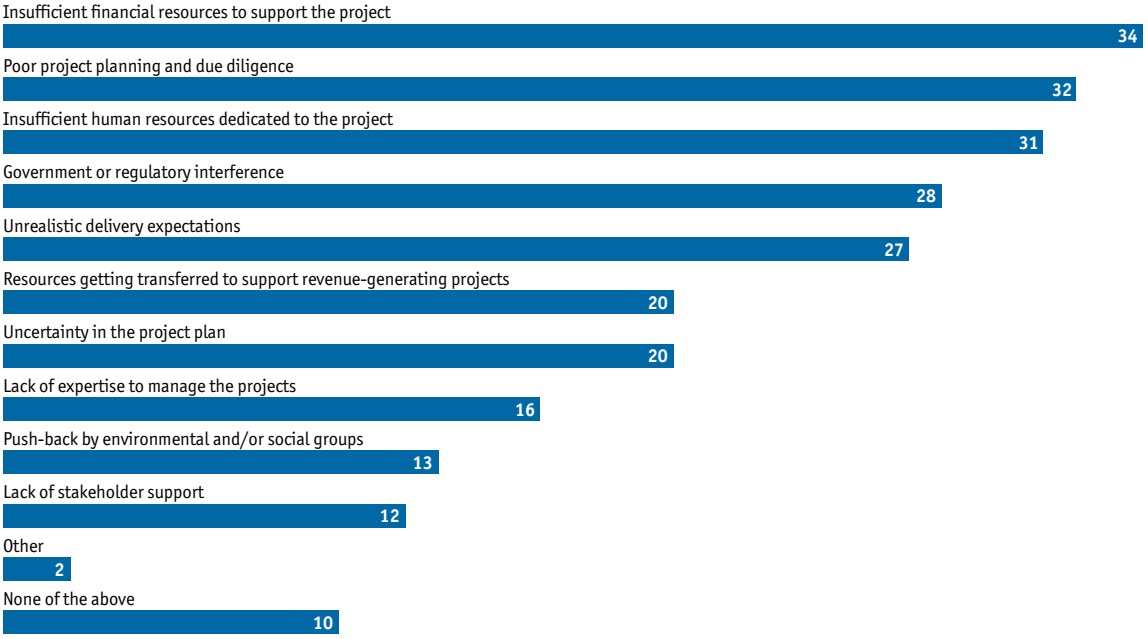
If that percentage is expected to decrease over the next five years, what will your infrastructure investment priorities be?

Please select up to three.
(% respondents)

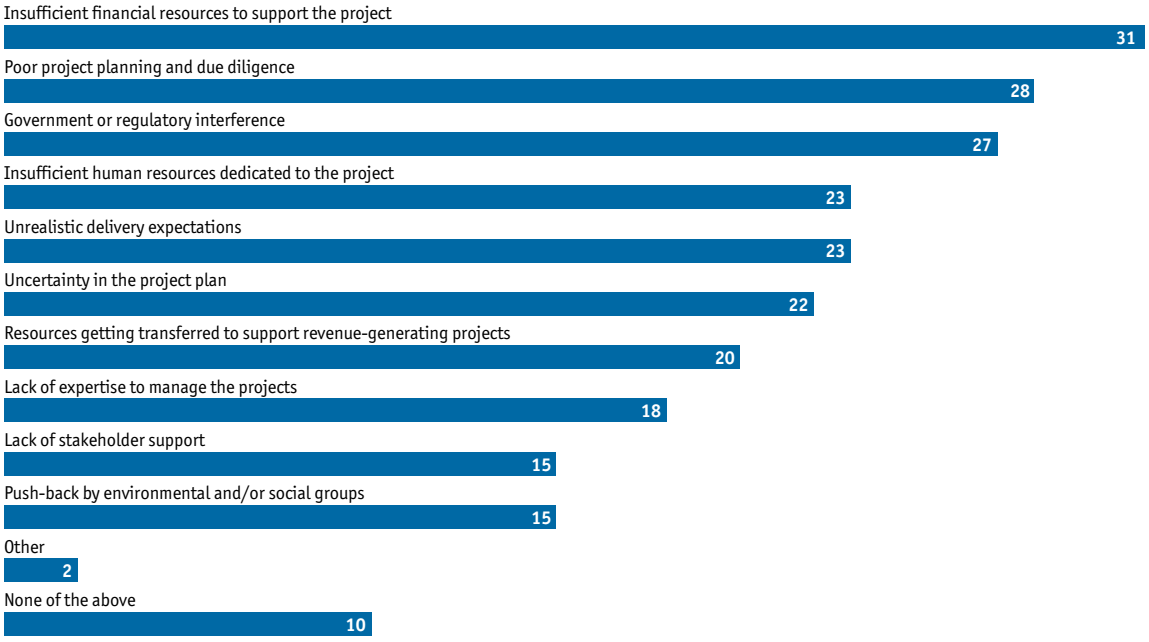


How effective is your organisation at upgrading ageing infrastructure relative to your competitors?
(% respondents)

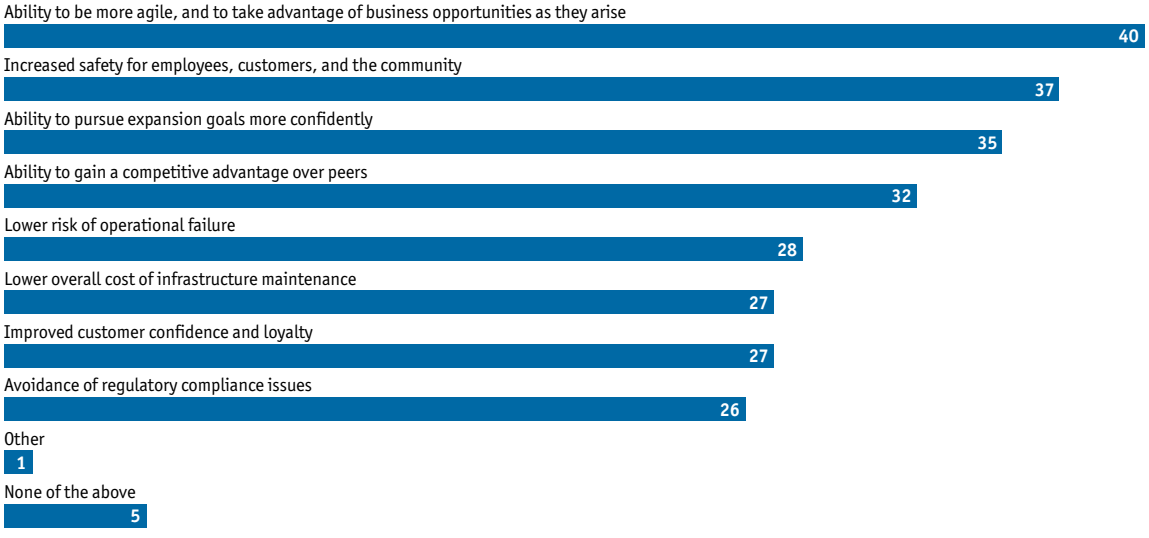
In your opinion, what are the biggest obstacles to delivering successful infrastructure upgrade projects in your organisation? —On schedule
Please select the top three.
(% respondents)



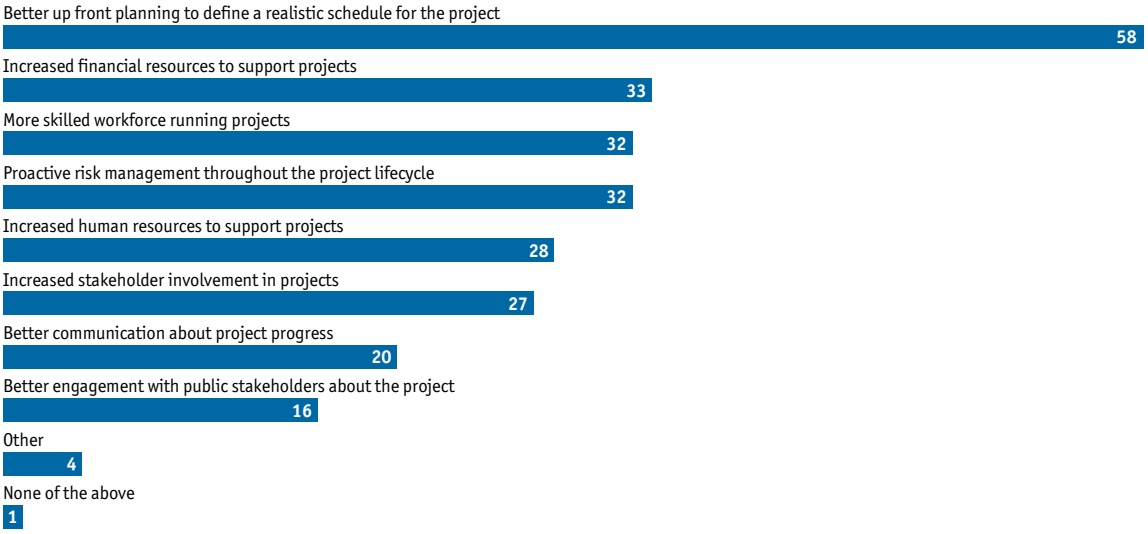
In your opinion, what are the biggest obstacles to delivering successful infrastructure upgrade projects in your organisation? —Within budget
Please select the top three.
(% respondents)



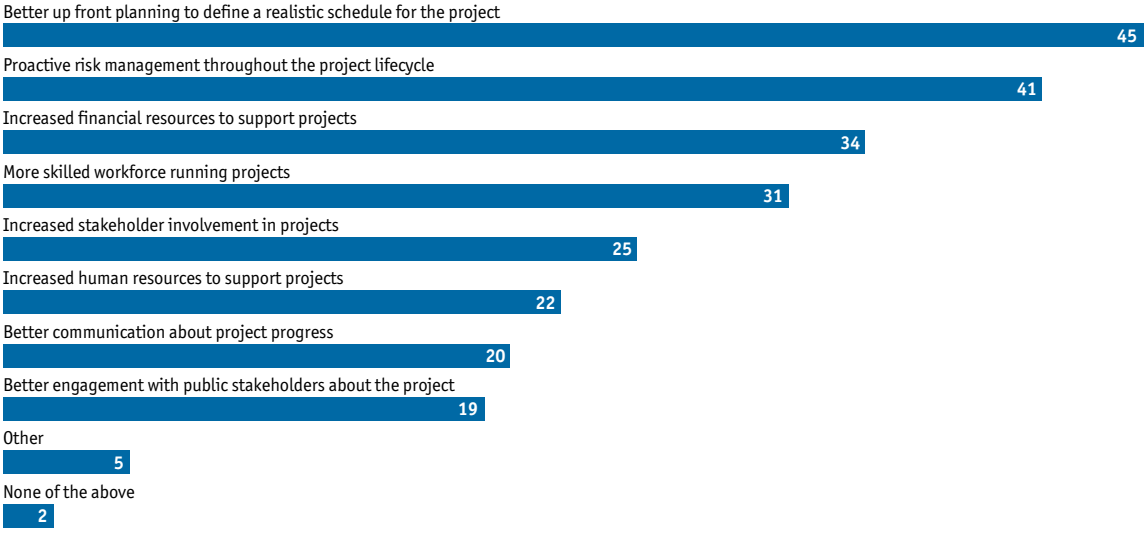
In your opinion, what are the greatest benefits of proactively addressing ageing infrastructure upgrade issues?
Please select the top three.
(% respondents)



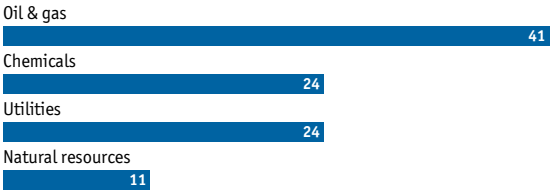
In your opinion, what would help you overcome these obstacles in the next five years to bring infrastructure upgrade projects in on time and on budget? —On schedule
Please select the top three.
(% respondents)



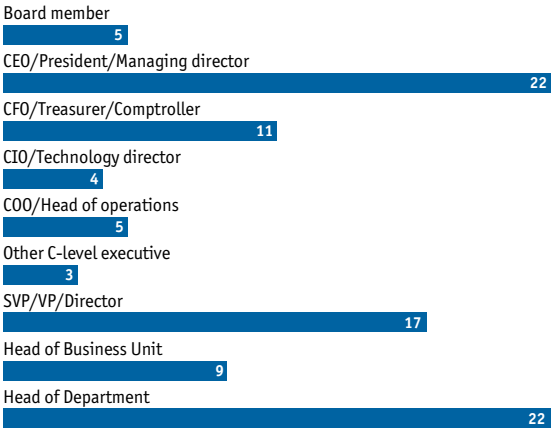
In your opinion, what would help you overcome these obstacles in the next five years to bring infrastructure upgrade projects in on time and on budget? —Within budget
Please select the top three.
(% respondents)



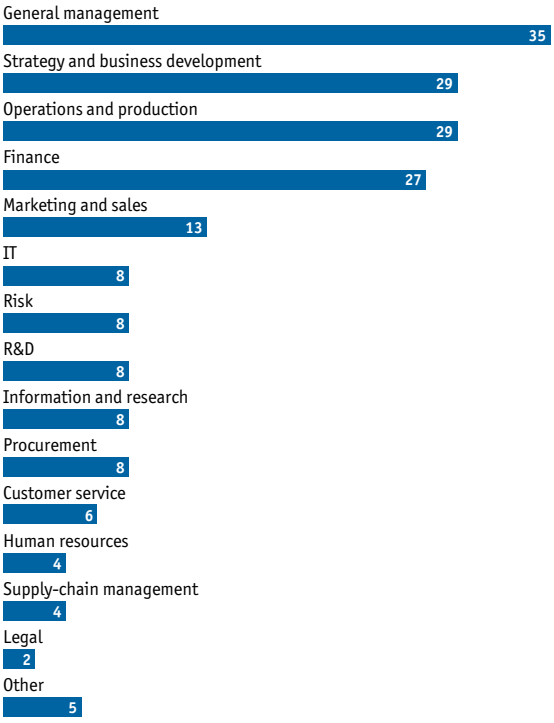
What is your primary industry?
(% respondents)



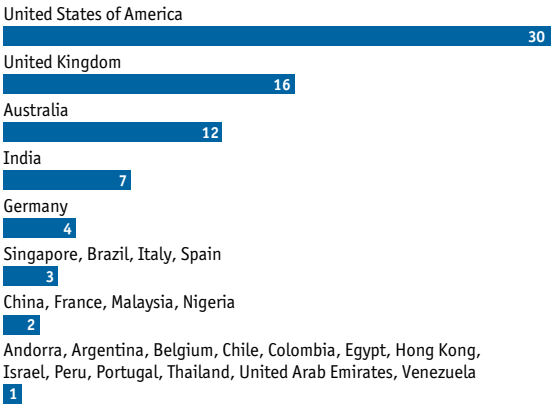
Which of the following best describes your title?
(% respondents)



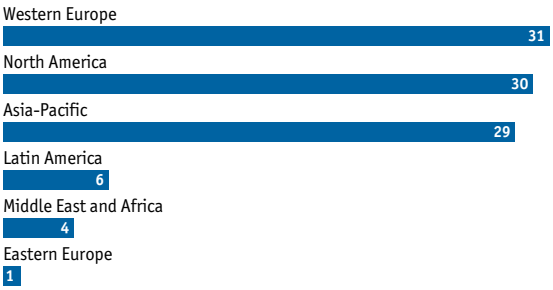
What are your main functional roles?
Select up to three.
(% respondents)



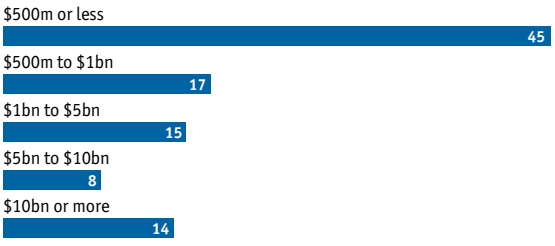
In which country are you personally located?
(% respondents)



In which region are you personally located?
(% respondents)



What are your organisation's global annual revenues in US dollars?
(% respondents)



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