

ATKINS

Member of the SNC-Lavalin Group



Digital Reality

How physical infrastructure is evolving in a world of data

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Executive summary

We live in an increasingly digital world. Rapid advances in technology are disrupting established ways of doing business. Problems that were once solved by simply building something new are increasingly being tackled digitally or by applying technology to existing physical assets.

As a world leader in infrastructure projects, Atkins has been at the forefront of integrating digital technology into physical assets. Using our experiences and seeking the insight and opinion of leading infrastructure figures through telephone interviews, we have created this report to explore the opportunities and challenges created by the digital revolution.

Our research results highlighted that industry leaders are resoundingly optimistic about the opportunities presented by the convergence of the physical and digital worlds.

Digital Reality explores this optimism, using observations from the research to consider how digital advancement in the workplace is changing business operations. Innovations introduce disruption, and businesses therefore need to evolve to capitalise upon this new technology and its promised efficiencies. They also need to develop a greater understanding of the status of their assets and adopt new business models to meet rapidly changing market demands. Implementing cultural and behavioural change will be key to convincing staff to embrace more agile working habits.

The report looks at how the pace of change can be bewilderingly fast, as the bond between humans and machines grows closer. Organisations need to consider not only how new technologies integrate with existing infrastructure, but also how people interact with them. Automation, digital twins and additive manufacturing all offer a range of efficiencies and advantages. However, thought needs to be given to the software and hardware required to support these disruptive innovations, such as the huge servers or Wi-Fi connectivity needed to run hundreds and thousands of connected and autonomous vehicles.

Big data and analytics, artificial intelligence and the Internet of Things are identified as the top three digital disruptors, while the top technologies currently in use by infrastructure organisations include 3D printing, autonomous vehicles, drones/UAVs, artificial intelligence and robotics. While investment is being made available to embrace these new technologies, 60% of

our industry figures revealed that it will take them over two years to become digitally enabled.

We also examine the difficulties companies are facing to keep up, particularly in ensuring that their staff have the right skills. Organisations must review their staffing strategies and look at which skillsets, systems and attitudes are required, the cultural changes that must be adopted, and whether they need more or fewer people. In the face of a widening skills gap, businesses must consider whether to recruit new staff, or cross-skill existing employees.

Big data represents both an opportunity and a challenge. While more and more data is generated by a growing number of devices and assets with in-built sensors, many businesses still do not know what to do with it, or how to extract value from it. Infrastructure organisations that do so are able to make more informed, strategic decisions. They possess a real-time awareness of the status of their assets, can predict how those assets will behave, and know how and when to repair them. In fact, Digital Asset Management of any critical infrastructure can lead to savings of up to 30% in maintenance and operation costs.

But it is key that an organisation's assets are as secure as they are efficient. Infrastructure organisations face unique challenges when it comes to the introduction of digital innovations, thanks to the prevalence of legacy assets that often have a lifespan of decades. Much of this infrastructure is also safety-critical and it is paramount that it remains resilient to new vulnerabilities created by the increased interconnectivity of systems. This is particularly relevant given the introduction of the General Data Protection Regulation, the Network and Information Systems Directive, and other pieces of legislation around the world forcing organisations to comply or face fines for failing to secure customers' personal data or protect critical national infrastructure systems from cyber attack or digital disruption. Wherever possible, it is key to include security in the design, but that security must also continue to evolve to meet a rapidly changing threat.

The report concludes that by looking at business transformation, the pace of technological change, people and skills, the intelligent use of big data, and resilience and security, organisations will be well placed to embrace the opportunities of the Fourth Industrial Revolution and successfully grow alongside it.



The new digital reality

Over the last half-century, the world has been transformed by a digital revolution. The journey from the first computer chip to the Internet of Things, virtual reality and artificial intelligence has happened astonishingly quickly, and is leading to the convergence of the physical and digital worlds.

In a 2015 New York Times interview to celebrate the 50th anniversary of Moore's Law – the extremely accurate prediction by Gordon Moore, co-founder of Intel, that the amount of processing power on a single computing chip would double every 18 months to two years – the writer Thomas Friedman explained what that meant. Intel calculated how a 1971 VW Beetle would have changed if it had improved at the same rate as microchips did under Moore's Law: the car would be able to travel at 300,000 miles per hour and run for two million miles per gallon of fuel, at a cost of just four cents.

The rapid pace of improvement has meant that developments that were simply unthinkable five years ago – offshore wind power cheaper than nuclear or gas, or thousands of driverless cars being tested on roads across America – are not just feasible but here, and well on the road to commercialisation.

Technology is not just creating new capabilities and massive improvements in performance; it's also upending traditional business models and value chains.

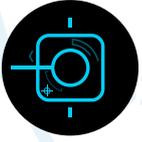
As an example, many millennials no longer consider purchasing a car, but prefer to use Uber or technology-enabled car-sharing services like Car2Go, a subsidiary of iconic auto manufacturer Daimler. This change affects not only auto manufacturing, but also auto insurance, and auto mechanics, by consolidating the purchase of these previously independent elements and offering them as a combined on-demand service.

The built environment and its infrastructure is not immune to this trend, and digital technologies – Building Information Modelling (BIM) and digital twins to machine learning and artificial intelligence – create enormous opportunities to improve and consolidate the design, planning, construction, operation and maintenance of physical assets. However, the new digital landscape is also marked by new risks such as data privacy, data integrity and cyber-attacks.

This report looks at some of the key issues that the new digital reality creates; how it is changing the way businesses operate; how to keep up with the rapid pace of technological change; what new skills are needed to enable organisations to make the most of digital opportunities; how to get the most out of big data, and how to ensure that your assets remain resilient and secure.

The convergence of our digital and physical worlds is not futuristic: it's here now. Considering the implications and opportunities that this digital transformation offers is vital to set us on the right course for a prosperous and sustainable future.

Phil Gruber,
Global Leader for Digital Asset
Management, Atkins



60%

believe their organisation is over two years away from being digitally enabled

Research overview



Digital revolution survey

As part of this report, Atkins carried out a survey of key industry figures, gauging their reactions to the impact of the digital revolution on their businesses.

There was an overwhelmingly optimistic reaction to digitalisation, with 97% of respondents saying that they thought it was inherently a positive development for their industry.

Most respondents thought they were reasonably well prepared for digitalisation, with 63% saying their organisation had only a small skills gap in this area, and 13% saying the gap was extremely small. Just 16% said the skills gap was large or extremely large, although a further 6% were unsure.

However, among those with concerns was Charles Ndungu of Triad Architects, who said that one of the biggest challenges was ensuring that employees had the necessary

skills to effectively use new technologies and software. "A lot of new technologies and software are coming up and staff skills have to keep up with these, so we have to invest a lot in training," Ndungu said.

This is compounded by a wide concern about the pace of change and the dangers of keeping up or betting on the wrong type of technology. Paul Hide of TechUK said that his organisation's biggest worry was making the right decisions, on the right digital technologies. He said, "There is a huge range of choices, so you always have to make a calculated risk in the timing of when you transform and what you transform to. There is a risk that you transform at the wrong time, too early or too late, or you go down the wrong route."

Skanska's Linda Colman wondered whether "the industry as a whole understands the value and the benefit of the digital agenda, and whether they all receive the level of investment that they need to make, given the potential impact of the technology."



My biggest concern is the risk of people becoming more disconnected from the environment around them. If everything is virtualised there is a loss of real world experience and people become more isolated from the physical world. ”

Anonymous

One respondent said that their sector was plagued by risk aversion: “Customers are still holding on to legacy mindsets. Even if we show them a hugely compelling business case, there are still historic concerns about the risks of adopting those digital models.”

Another of those surveyed confirmed this reluctance to embrace new technologies, saying: “Anything that has innovation, we really don’t get involved in, so we are very much adopting mainstream technologies rather than trying cutting edge ones. The challenge is that we feel our customers are changing and demanding more and more innovation or newer products.”

Despite these fears, most organisations believe they are making progress, with 80% of respondents saying their digital capabilities had improved in the past year.

Yet the digital landscape is changing so rapidly that it is hard for businesses to keep up:

“In my world, the major challenge is the speed with which digital technologies are transforming and improving on their own,”

said one respondent to the survey.

While virtually all those questioned (97%) said funding would be available for digital investments, 60% thought it would take over two years for their organisations to become digitally enabled. That is a problem, when, as Colman says, “There are so many systems and software packages out there. Understanding what the right thing is for us when you have got no commonality and no one go-to place is a real challenge.

“There are a lot of start-up companies developing really clever things, all of which will help. So, the biggest challenge is fighting your way through that massive technology development and deciding where you are going to invest your money and what you are going to adopt, and understanding how it will really work in practice.”

However, said one respondent, there are real fears that “the rapid pace of change in some of these markets means there is a chance you place a bet on the wrong technology or the wrong digital process. Hence, we require people to come and help guide us to the right and appropriate answer.”

TechUK’s Hide adds, “The process of upgrading and changing technologies can be both complex and disruptive, and therefore more expensive, so we find changing to a new system to be very challenging.”

When asked which technologies would be the most disruptive, 29% of survey respondents pointed to big data and analytics, 25% highlighted artificial intelligence, and 13% said the Internet of Things.

“A lot of industries, including ours, will be heavily disrupted and in the end, it will all come down to productivity and costs,” said one construction and infrastructure firm. “Automation will provide the next business case with new technologies in the future. That will potentially put a lot of people out of work very quickly and that is not what we are looking to do.”

But they added, “The biggest opportunity

is automation that makes everything safe, so we don’t have to put people in hazardous environments underground, at height and in confined spaces.”

Anecdotally, the biggest risk raised by the shift to digital ways of working lies in the resilience and security of systems. Many survey respondents expressed concerns about the need to balance the personal security of customers’ data against the value that the data creates. “Security is the biggest concern. Because everyone is talking about openness, interconnectedness and so many platforms and mediums,” one company said, “the biggest concern will be to see how secure we are, as one loophole can bring the entire system down. No matter how secure you are, people will find ways to crack your system.”

There are also fears about people being left behind by the digital revolution. “My biggest concern is the risk of people becoming more disconnected from the environment around them,” explained one of those surveyed. “If everything is virtualised, there is a loss of real world experience and people become more isolated from the physical world.”

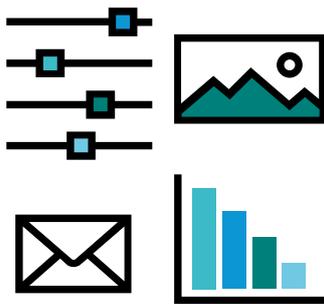
However, one respondent highlighted

how high the stakes are in the digital transformation: “I think simply the challenge is ‘change or die.’ If you are not prepared to investigate, exploit and deploy the digital capabilities in your business, you will lose business. You will lose customers, you will lose market share and you will lose economic prosperity. Because the customers have that choice, the capabilities are available and if you don’t offer them, your competitor will.”

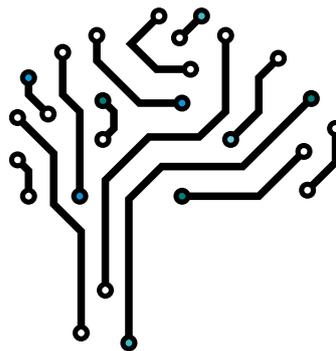
“I genuinely believe we are on the cusp of a massive transformation and I’m not sure if we are ready for it, but it’s coming and it will be a reality everyone needs to prepare for.”

Pete Mellish,
Chief Technology Officer,
Manufacturing, Utilities & Services,
Microsoft

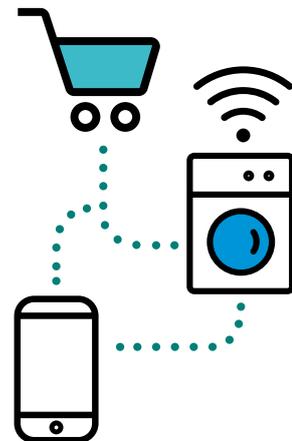
What technologies are going to be the most disruptive?



29%
Big data
and analytics



25%
Artificial
Intelligence



13%
Internet
of Things



Business transformation

Digital innovation and agile working

There is great excitement across industries about the impact that digital technology will have on business operations. However, there is less clarity about exactly what the digital revolution will mean for the way companies do business.

While it is clear that embracing digital will be a prerequisite for success in years to come, “what being a digital business means is multi-faceted”, says Ben Kirk, a Director of Business Development in Atkins’s Infrastructure division. “There is a heavy dose of technology, obviously, but there is also a lot of disruption.”

Some of the signs of the digital revolution are obvious, he adds, “such as the greater availability of smart mobile devices and data, but it is also manifesting itself in the tools used to help organisations become more efficient.”

The less obvious side of this revolution is the need for businesses to evolve in order to get the most from the technology on offer. Organisations cannot simply bring new technology into an existing business and expect it to change everything for the better.

The business itself needs to adapt in a variety of ways to get the most from technology, and, more importantly, to achieve even more successful commercial outcomes.

So while organisations are waking up to the fact that the advent of digital opens up new opportunities, they either don’t know where to start or they don’t know how to progress, says Phil Gruber,

Atkins’ Global Leader for Digital Asset Management. “Many companies have spent a lot of time and money on this and the results have been mixed,” he adds.

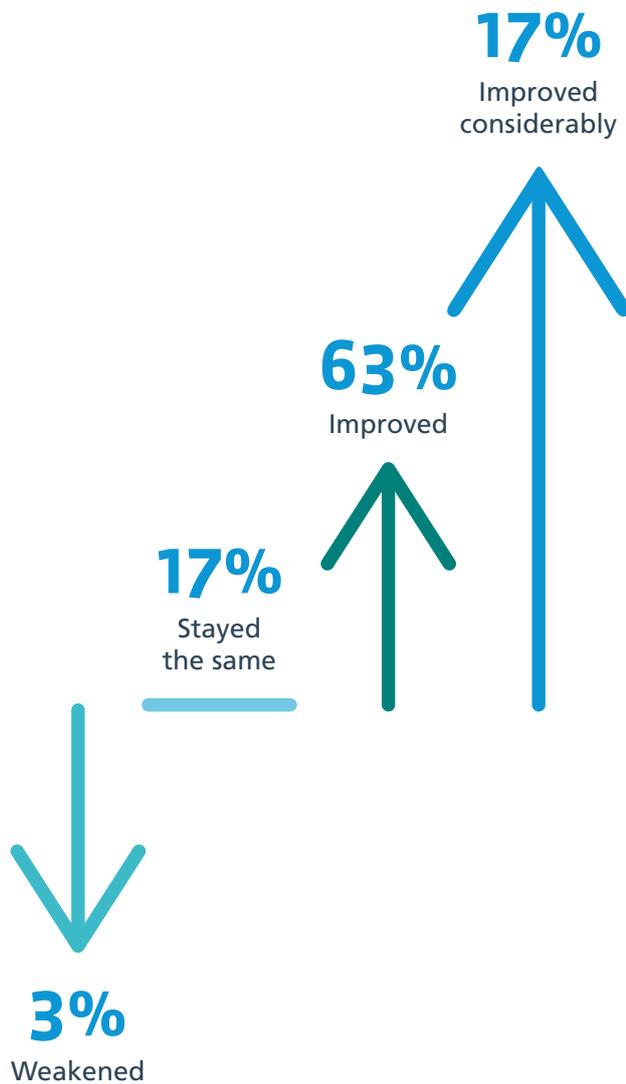
If we look at the technology, there are a number of clear issues with which companies are dealing. Information is regularly held in a variety of formats, says Kirk: “Companies often have a patchy mix of tools, ranging from a software programme to spreadsheets to documents gathering dust in a filing cabinet. The Holy Grail is to get to a situation where all the data is in one place and the person responsible can access and use the data to achieve more efficient outcomes.”

Companies are, however, harnessing digital in more creative ways; for example, utilities are not only using outage management systems to monitor when the power goes off, but social media too – often comments on Twitter can be the first indication of a problem.

The availability of data and the ability to marshal it has also enabled the rise of new businesses such as Uber and Airbnb, which unlock previously untapped personal assets of transport and accommodation. Aerospace engine manufacturer Rolls Royce has for years operated with a business model that sells the service of “thrust” rather than selling engines. This model of offering products as a service has spread to sectors across the economy, from lighting to jeans to medical scanners.

But such models only work because of the digital infrastructure behind them, points out Gruber: “If you didn’t have this real-time information about assets, ‘as-a-service’ models wouldn’t work.” So, despite the

Has your company's digital capability improved or weakened over the past year compared to peers?



proliferation of data that is now available thanks to the Internet of Things and a plethora of sensors, "most companies are still grappling with the basics – what do I have, what condition is it in and what maintenance does it need?" says Gruber.

And the reality is that even if organisations have a reasonable knowledge of what technology they have and how it can help them manage their assets, many of them are only just appreciating that business transformation is not only about the technology. David Strange, a Client Director in Atkins' Aerospace, Defence, Security & Intelligence division, says, "To take advantage of the technology, you have to build the organisational capability to respond to what it can do. It is as much about culture and behavioural change as it is about process change."

Gruber adds, "The technology is usually the easy part – it's getting people to change the way they work that is much harder."

More agile ways of working are transforming the way businesses work, as top-down management is replaced by more self-managing teams, with individuals given much more responsibility to make their own decisions and to react to developments as they occur. "Employees are becoming more demanding in this regard as well. They want to be more empowered," Strange says. "Senior managers need to be comfortable giving people more responsibility."

Agile working also helps deliver products more quickly, through initiatives such as two-week planning sprints. However, Strange stresses that while by nature these are about not planning too far in advance, it is absolutely not the case that there is no need to plan. Indeed, such short-term timelines create more accountability by increasing the frequency of oversight. "The same amount of rigour is needed and you need to retain an overarching framework," Strange adds.



The winners will be the companies that embrace digital change fully and wholeheartedly and use it to maximise their productivity. ”

Anonymous



Transformation needs to be done with a proper change programme, led by business leaders and not IT departments to ensure it is embedded in the business, not seen as something being done to the business. ”

Anonymous



88%

believe their digital capability has improved compared to peers

“The trick is to enable more empowerment and flexibility without losing a clear vision of what you are trying to achieve.”

Further, digital advances create opportunities for greater innovation by making it possible to try something in a “fail fast” culture and, if it doesn’t work, move on without incurring massive costs. It also increases collaboration, breaks down silos between different departments and between customers and suppliers, and increases the opportunities for new ideas and new ways of working.

But companies need to act fast to take advantage of this dividend, and they need to pick advisors carefully, ensuring that they understand their company and sector as well as the companies do themselves, while also having a grasp of the technological issues. “We are moving from acting on demand to telling people:

‘we can help you in ways you have never even thought about, to do things you have never even thought about,’” Gruber says.

“The opportunities are out there,” he adds. “The assets are talking to us, but are we listening?”

Pace of change in technology

The relationship between humans and machines

Our world is changing faster than ever before, with technologies emerging that have the potential to revolutionise the way we live and work together.

However, there is a danger that technology advances so quickly that there is a disconnect with the people that it was designed for, says Caroline Paradise, Head of Design Research at Atkins: "It's important to remember the human aspect of design – how the user fits into this changing world and how they engage with and use the technology. As consumers of the built environment and infrastructure, people are central to this."

All this new technology has to fit in with existing infrastructure, she adds. "We need to think about how new technology interfaces with the world we currently live in as well as a future state."

To this end, Atkins has just taken on a cyborg ethnographer, to study and explain to clients the relationship between humans and machines. "We hope to reinforce the importance of the relationship between humans and assets," says Nathan Marsh, Atkins' UK & Europe Director for Intelligent Mobility.

"I worry that people are building the most advanced technology and not dedicating enough time to really understanding the human-related implications of robotics and automation," he adds. "Human acceptance of next-generation technology is key."

The wider consequences of individual technological developments are not always thought through, he adds: "Autonomous

vehicles are really, really smart, but that is just the tip of the iceberg. When entire vehicle fleets are autonomous, it could challenge the need for all sorts of things we accept as normal, such as bus stops, car parks, personal insurance, or even driving lessons."

The factors that may limit the spread of technology are not always obvious, either. "The big challenge for autonomous vehicles might not just be in the technology – it will be whether we have enough fast and reliable Wi-Fi connectivity to keep vehicle networks running and safe," says Marsh. "Also, will we have enough server space? One state-of-the-art autonomous car running for 15 minutes generates as much data as the Large Hadron Collider, and we need to model in what 100,000–200,000 of these vehicles will need, and generate, to keep us confident that we are ready for them. Server space and Wi-Fi are not going to make headlines, but they're absolutely crucial parts of technology acceptance."

Despite these potential barriers, digital is offering clear benefits when it comes to asset management, by combining with other technologies to improve the way we design, build, operate and maintain physical assets. For example, components that need replacing can now be 3D printed directly from a 3D digital model, and we can create a "digital twin" of an aircraft that acts both as a blueprint for the particular type of plane and a record of the life of an individual aircraft, and that tracks any modifications over the duration of its operational life.

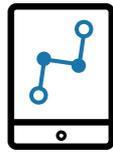
"We can monitor the performance of an entire fleet, manage the maintenance schedule much better, predict how damaging each flight is and know the status of an aircraft without having to inspect it manually. This means we can manage its performance much better," says Andrew Munday, Head of Advanced Engineering

How long before your organisation becomes digitally enabled?



13%

Our organisation is already digitally enabled



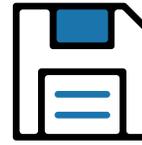
10%

0-1 years



17%

1-2 years



37%

Up to 5 years



23%

Over 5 years

at Atkins' Aerospace, Defence, Security & Technology division. "Ultimately, it enables you to make much quicker and better decisions about the management of assets."

The pace of change has been so rapid in part because "the advance in processing power is happening at almost breakneck speed," says Marsh. This opens up new possibilities; for example, the use of artificial intelligence to rapidly make precise judgements that previously would have taken much longer, or would have required a certain amount of guesswork.

Other technologies and techniques allow engineers to approach product design in a completely different way. Topology optimisation, for example, inputs the parameters and constraints of a product into a programme that then comes up with the most efficient design, rather than the previous method of looking at what the product needed to do and coming up with a best guess of what it should look like.

This method has been enhanced by new design freedoms created by the advent of 3D printing or additive manufacturing. Because the process starts with nothing and prints products layer-by-layer, it is possible to create shapes that are not possible when using the traditional technique of taking a lump of metal (or plastic or other material) and taking bits away. For example, components can be made that are mostly hollow, and therefore much lighter but still as strong as their solid predecessors.

The development of new advanced composite materials is reducing the weight and increasing the life of components. Further, because composites are created layer-by-layer, sensors can be embedded within them for through-life monitoring. In

the future, substances such as graphene, which is conductive, could in some cases remove the need for separate sensors altogether. Then there are the changes in the energy sector, which is moving from a fossil fuel-powered world towards greater use of electrical power and renewable energy, as well as a shift to greater autonomy in vehicles. These trends are complementary – it is much easier to make an autonomous electric vehicle than one powered by internal combustion. "Electric propulsion is much more suited to the digital age," says Munday. And even when vehicles are not being propelled by electricity, it is still playing a greater role – in aircraft, for example, where electric systems are replacing many hydraulic, mechanical and air systems.

All these technological developments have changed what is possible more quickly than regulators, designers, engineers, individual companies and in some cases entire industries can keep up with. "We operate in industries that are quite heavily regulated," explains Munday. "It is regulations and people's mindsets that are holding up the pace of change, not the technology."

Sometimes there is a lack of confidence about adopting new technology, and designers steeped in a particular way of thinking struggle to adapt to the new possibilities. Using additive manufacturing as an example, Munday adds "It can be difficult when you have spent your entire working life



93%

believe that technology is important in fostering customer relationships

How likely is it that your company will make funding available for digital investments in the future?



3%
Unlikely



20%
Likely



77%
Highly likely

designing from the outside in to suddenly change to designing from the inside out.

Then there is the risk for companies, particularly large corporations, that are so invested in a particular technology that they cannot move on. A wide range of sectors, face the danger that they end up competing with the wrong people – car makers may focus on their rivalry with other vehicle manufacturers, while their new rivals could actually be Google, Uber and Apple.

The same risks apply to knowledge-based companies such as Atkins, whose main asset is their expertise.

Here, there is a risk that progress will be held back by a skills gap, which we explore in the next chapter of the report, but equally this is an opportunity for

Atkins to leverage the fact that it can offer both engineering and IT expertise in a way that is closely aligned. And while many lower-skilled tasks may become redundant, the need for high-end skills and analysis will only grow.

The advent of digitalisation has created an extremely powerful set of tools that engineers can access, but they are still trying to achieve the same things, Munday says: "It's all about the outcome, about solving problems. Digital just allows us to do it better, and more quickly."

Concepts such as the digital twin have even created a new asset class for investors, says Marsh: "Conventional infrastructure is a very established and pretty secure asset class. Digital infrastructure, particularly

digital twins of transport infrastructure, is a new asset class, and as yet unproven and unrated at scale. Whilst they have completely different risk profiles, both have a value to users and investors. Thinking ahead, I think they are different sides of the same (bit)coin."



The biggest challenge is that the technologies are changing so fast that by the time you implement one, the next one is already there. ”

Anton Koekemoer,
Director at Boogertman and Partners Architects



The rate of change is just limited by people's imaginations, budgets and their ability to adapt and embrace new technologies. ”

Pete Mellish,
Chief Technology Officer, Manufacturing, Utilities & Services, Microsoft



97% | are likely to make funding available for digital investments



How are people or various generations of the workforce able to adapt to the digital transformation? How do we make sure we do not leave people on the road? My biggest fear is we are creating two worlds: the digitally connected new generation and the rest. How do we lessen the gap? How do we embrace everybody? ”

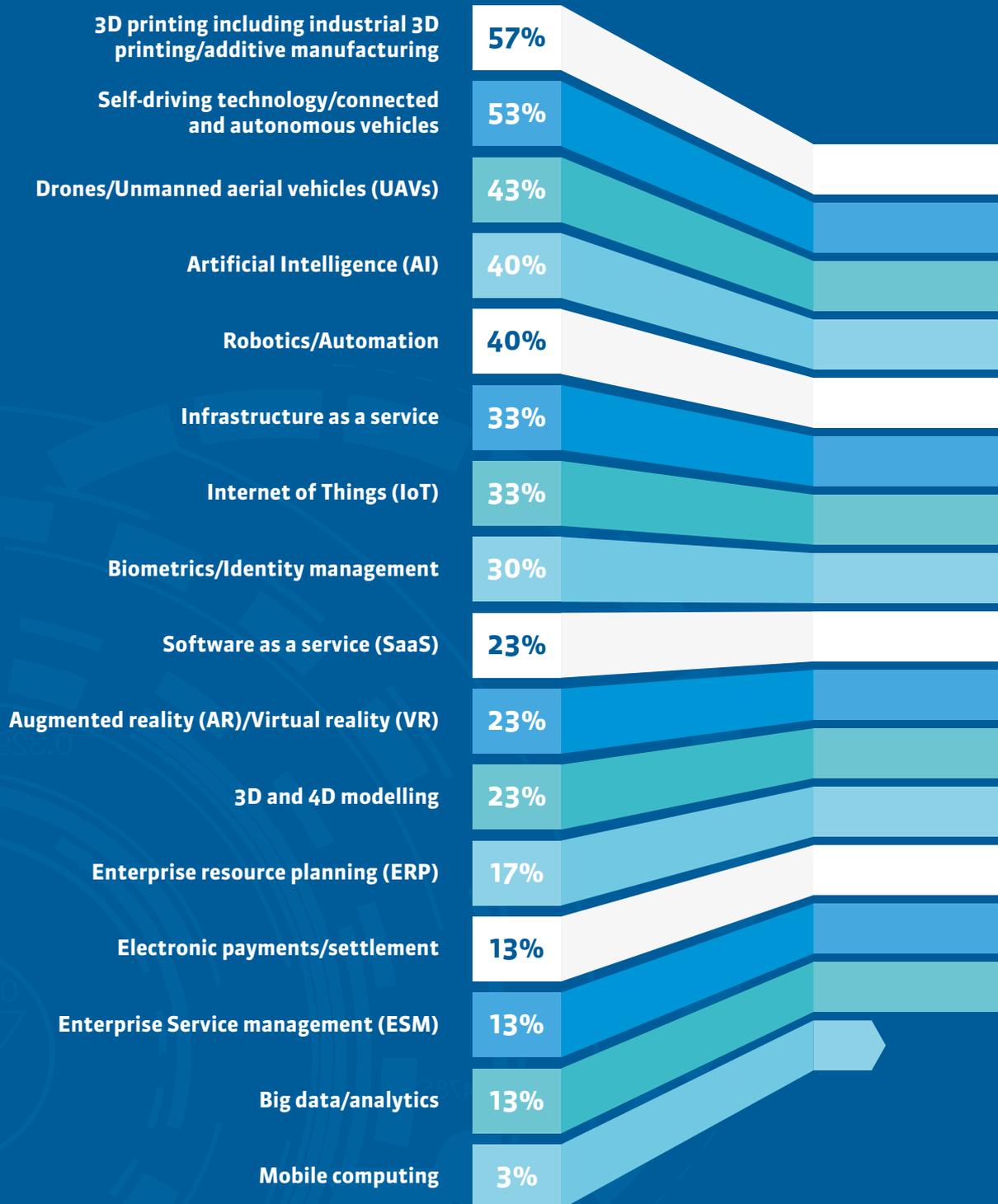
Fabrice Dreneau,
Director, Customer Success EMEA & APAC, World Wide Sales & Services, Autodesk



Technologies in play

Plenty is said about the technologies of the future, but which technologies have organisations already invested in?

What technologies are currently being used?



“

The thought of an amoral spectrum of AI's that are able to converse with one another without our ability to understand or interpret them could potentially be disastrous for human civilisation. However, the power and capabilities that they can bring are incredibly positive, as long as we do it in the right way and instill ethics within their core. ”

Pete Mellish, Chief Technology Officer, Manufacturing, Utilities & Services, Microsoft

“

The latest camera, drones and screening data allows us to connect the community better without the need to disrupt workers. The biggest opportunity is automation that makes everything safe, so we don't have to put people in hazardous environments, underground, up at height and in confined spaces. ”

Anonymous

Extracting value from assets

Many of those surveyed face specific challenges in understanding how to use technology to better manage their assets, realise efficiencies and minimise waste. So how can organisations extract value from the digital revolution and change the way they do business? Digital Asset Management has a key role to play.

It involves the use of data and technology to reduce costs, control risks and improve whole life asset performance. There are four key dynamics that create opportunities for infrastructure organisations.

1. The information gap between the design/construction of assets and the maintenance/operations of assets is closing.

Driven by data standards, BIM, and software applications used in different phases of the asset life-cycle, the disconnect between information in pre-construction and post-construction is evaporating. Over the life of the asset, most owners spend only 20% on design and construction and 80% on operations and maintenance. However, historically the information developed during design and construction was not fully utilised to optimise the maintenance and operation of assets. This is changing, and will drive significant efficiencies in managing assets, as well as informing future design.

2. The rise of the Internet of Things and Artificial Intelligence will drive significant efficiencies in the maintenance and operation of physical assets, as well as opportunities for new business models.

The proliferation of data available from sensors, mobile devices and other sources is growing exponentially, is readily accessible via the Internet of Things, and is made intelligible and useful through advances in Artificial Intelligence. Mining intelligence from new data sources can improve performance and reduce costs and risks associated with operating and maintaining assets. The availability of this data can also be used to drive new value from assets. Common examples are Uber and Airbnb, both of which drive additional value from common assets (cars and homes) using new business models.

3. Most asset owners are still grappling with the basics such as what assets they actually have and the condition they are in.

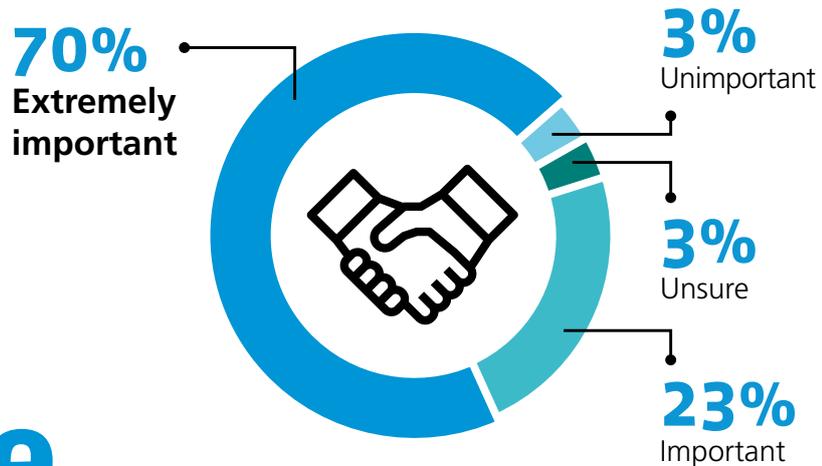
Optimised business processes, supported by an Enterprise Asset Management system, are essential to drive value from new technologies or to fully leverage information available from design and construction. In addition, the right processes supported by a functional system will help drive cost efficiencies and performance outputs. Asset owners can then easily identify which assets they have and their condition, allowing prioritisation of investment in maintenance, when it happens and who will do it.

4. Asset owners are under immense pressure to increase asset performance and reduce asset investment. They are increasingly looking to decision support tools to help optimise investment decisions.

The cost of operating and maintaining infrastructure often far exceeds available funding. Therefore, owners need a mechanism to make trade-off decisions about where they invest and to justify the need for additional funds. Big data and analytics capabilities now enable organisations to use decision support tools and trade-off analysis to see where they can optimise returns.



How important is technology to fostering strong customer relationships?



People and skills gap

What digital means to people and culture

The shift to digital is a boon for industry, creating a host of new opportunities and efficiencies, but it is also creating a demand for new skills at a time when businesses already face considerable skills gaps.

While many of these are the obvious technology-based skills that you would expect, others are skills that are “softer” and less evident.

Among the technology trends that are gaining traction in infrastructure are big data, the spread of the Industrial Internet of Things, and advanced predictive analytics. The sector is also having to get to grips with the increasing automation of processes and developments, such as the use of drones, satellites and other tools for remote surveying and monitoring.

Keeping up with these and other developments is vital, says Sharron Pamplin, Atkins’ UK & Europe Human Resources (HR) Director: “We have an internal mantra at Atkins – ‘Don’t wait to be disrupted’. We are doing a lot of thinking about what the future will look like and what that will mean for our people and our business.”

Atkins now finds itself working more closely with customers, co-creating and

developing new solutions using techniques such as hackathons, lock-downs, and 100-day sprints. “We are learning together with our customers,” Pamplin says.

As a result, the way the firm looks at HR has changed, she adds. “We’re now doing HR from the outside in, focusing on the value HR work creates not only for those inside the organisation but customers, investors, and others outside the organisation.”

This shift demands a change in culture in a range of areas, not least in getting used to new business models. Whereas in the past, it was all about time on the job and materials used, “Now we are thinking about end-customer value and ways to use ‘risk and reward’ profit sharing,” Pamplin explains.

This can require new ways of collaborating, not just with clients but also with those clients’ other suppliers. “It’s a huge cultural change because we are reliant on other organisations for our success. Our success or failure is completely aligned with the end product that we all produce together.”

Another cultural shift that will be required in the new digital reality is a change in the relationship with data. Anne Kemp, a Technical Director in Atkins’ Infrastructure division, says that everyone must now take ownership of data, rather than it being solely the responsibility of the “techies.” “There has been a lot of focus on the drudgery of data rather than on its value, and the fact is that we need to treat it right so that we can extract from it the information that

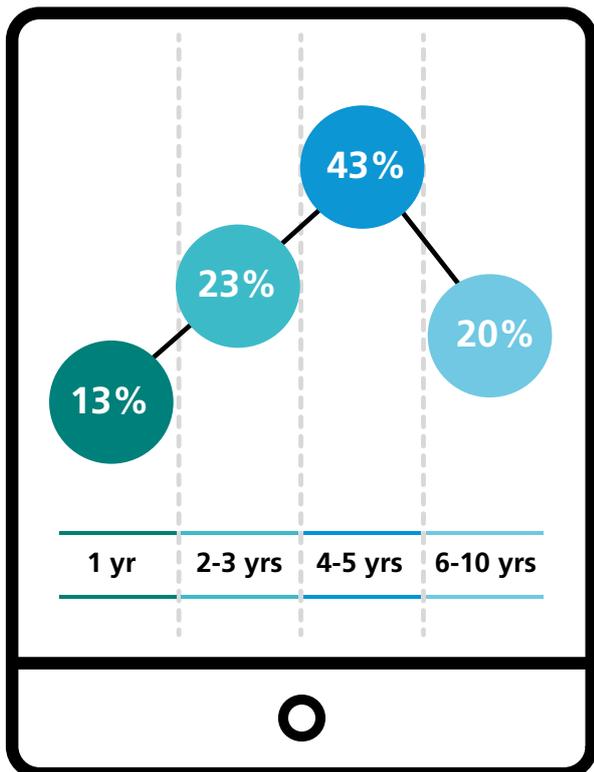
is useful,” she says. “Everyone needs to appreciate data and how valuable it can be.”

Part of this is about democratising data by making it available to everyone. “Knowledge shared is power,” Pamplin says, but Kemp adds that there must be a balance between this openness and having safeguards in place to ensure that people use the data appropriately and securely while also complying with all the relevant rules and regulations.

Employees also need to know the importance of using the right procedures to ensure that data is accurate and reliable. Concepts such as digital twins and 3D representations of buildings are very powerful, but thought needs to be given to the issues that arise from moving from presenting data in 2D to doing so in 3D. “Is there a danger of misinterpreting an image or, by contrast, trusting an image too much, rather than employing the fundamentals of your training?” Kemp asks. “We need to be clear about what is happening with technical assurance, what needs to be scrutinised, verified and agreed upon. With things like digital twins, we need to be clear who is responsible for keeping them up to date. If they are not accurate, the consequences could be really serious.”



How long before these disruptive technologies come into force?



HR is really changing in regards to the recruitment of new people and the types of digital skills each employee will need to have when joining a company. ”

Priscilla Oluga,
Senior Architect, Symbion Consulting Group



The technology that is available is generally ahead of people's current skill levels, she adds, particularly when it comes to collaboration. The key to successful collaboration is trust, and this can be problematic when people are approaching projects with differing objectives, skillsets and expectations. "Providing a framework which allows a wider perspective to take account of these differences allows us to find a way into the problem, and to start to develop a common language," Kemp says.

The need to consider these issues is leading to a fundamental reappraisal of the skills and people that companies need,

and even of the nature of work.

Firms need to ask what digital will mean to their staffing strategies

– will they need more or fewer people?
 What new skills and specialist knowledge will be needed, what processes and systems and what attitudes, behaviours and ways of working?

Once these requirements have been identified, you need to work out where you are going to get these skills and capabilities and what the balance is between hiring them in and developing them in-house. This includes identifying those individuals that will be your "critical value generators" and



Technology and digital channels supplement and improve human interaction as opposed to replacing it. ”

Kevin Ives,
Digital Transformation
Director, Arriva Trains

nurturing and developing them.

But there is also a need, having identified skills shortages, to look at “cross-skilling” to update the skills of those long-serving employees who are in danger of being left behind by technological advances.

Companies also need to widen the talent pool, not just in terms of gender and race but also in terms of skills. The advent of virtual and augmented reality is going to mean that gaming skills, for example, will be much in demand.

“We recognise that digital is the future of work,” says Pamplin. “We need everyone because there is a skills shortage and a people shortage. And diversity leads to a more

innovative, customer-focused organisation.”

Yet it is equally important to ensure that we are the masters of technology rather than the other way around. “Often in our relationship with technology, when it first emerges, the technology starts out as the parent and we act as the child. We need to have an adult-to-adult relationship with it, to ensure that we are using technology to help with the task in hand rather than for its own sake,” Kemp says.



The IT and digitalisation isn't the point of managing the transition between old and new technology, the point is to make things more efficient, easier and to allow customers and people to focus on the real issues rather than focusing on processes and systems. ”

Anonymous



The amount of data that we can derive, create and use about our customer or constituent is way beyond what we used to have – and growing. Effectively, we know where our customers are, we know their sentiment, we know their habits, and we often have great insight about their requirements. So, we can push out personalised service capabilities and offers in quite a proactive way before the customer has made a decision, thus influence the outcomes. ”

Jim White,
Industry Director – Public Sector – EMEA North, SAP

Intelligent use of big data



Extracting value

More than a decade ago, UK mathematician Clive Humby coined the phrase, “Data is the new oil,” adding that, “It’s valuable, but if unrefined it cannot really be used. It has to be changed into gas, plastic, chemicals, etc, to create a valuable entity that drives profitable activity; so must data be broken down, analysed for it to have value.”

Businesses are becoming increasingly aware that they have a powerful new raw material at their fingertips, but they remain unsure exactly how to extract the value from it. “The age of big data is upon us, and it is upon our clients,” says Dr Navil Shetty, an Atkins Fellow and a Leader in Digital Asset Management in Atkins’ Aerospace, Defence, Security & Technology division. “It is something that has only really developed in the last few years. Our clients are aware that they have this data, and

some are on a journey to understanding how they can use it. However, only a few have put in place systems to capture and analyse that data systematically and derive actionable insights.”

More than 20 billion devices are set to be connected to the internet by 2020, not just computers and phones, but everything from household appliances and heating systems to shipping containers and railway signals. They are creating exobytes – millions of terabytes – of new data every year. This data ranges from information on how assets are performing to environmental data such as temperature and air quality, along with mobile data that can tell you how customers are using an asset, and social media data that can provide a valuable insight into customer sentiment. New sources of data, such as drones, autonomous vehicles and augmented or virtual reality devices, are appearing all the time.



It is not just the amount of data that is an issue, but its complexity. “Big data can be defined as exceptionally large amounts of data that cannot be analysed by traditional data management systems,” says Shetty.

As a result of the development of the Internet of Things, virtually everything that is now made – from bridges to Fitbits – has sensors in it, that can capture data. In addition, the cost of storing data has fallen significantly.

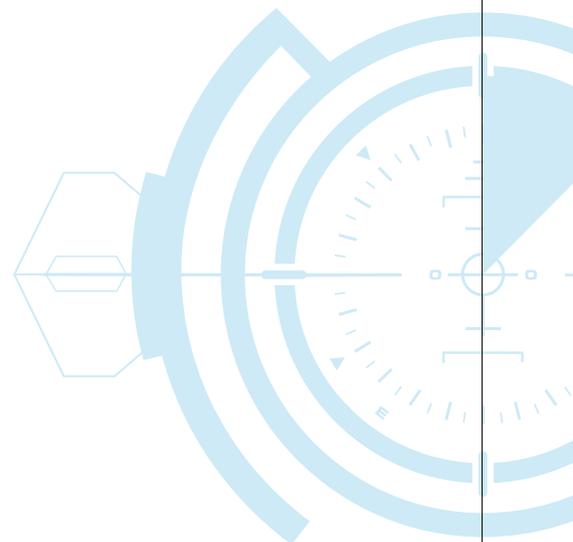
While companies are increasingly aware that they have data available, and that it can help inform decisions, many are struggling to know how to use it, says Atkins Senior Project Manager Dave Kelly.

When working with clients that are generating large amounts of often complex data, “you need people with specialised skillsets to help them make good business decisions,” he adds.

With the right help, the accumulation of all this information means that

organisations not only have greater visibility on how their assets are performing, they also have an ongoing record of performance. Increasingly sophisticated algorithms can then predict how they will behave in future and when certain components will need replacing.

This predictive maintenance translates into tangible benefits for customers – on the railways, for example, signal failures cause huge delays, infuriate passengers and cost rail companies millions of pounds. Being able to maintain and repair signals before they fail improves the passenger experience while enabling organisations to concentrate their resources to be more efficient. There are similar benefits for all sorts of major infrastructure assets, from baggage handling at airports to traffic management on motorways and offshore wind farms.





Using big data intelligently allows firms to interpret, analyse and learn from the prior performance of their assets in a way that enables them to improve their decision-making and plan better management of assets and systems in future through Digital Asset Management systems. However, data management skills are not enough. To get the most out of the data companies are generating, they need to marry this with deep industry knowledge as well.

“Ultimately,” says Shetty, “it will allow us to design better products and infrastructure projects. That’s the real prize we’re looking for. It’s very, very powerful.”

Digital Asset Management of any critical infrastructure can lead to savings of up to 30% in maintenance and operation costs, Shetty says.

Yet not all assets are currently monitored, and where they are, it is not always the right data that is being monitored. To get the most out of your assets, you need to understand both what

data you are currently collecting and what data you need in order to improve your ability to make decisions.

Initiatives such as Digital Railway, Digital Built Britain and Smart Cities UK show that the concept of Digital Asset Management is starting to gain traction. And as sector-wide schemes, they illustrate the benefits that can come from widening out the scope of analysis from individual assets to entire industries or cities.

As Kelly says: “The whole purpose of gathering data is to turn it into something useful – to transform it from data into information that can be acted upon to make strategic decisions.”

Resilience and security

The dangers of digital disruptions

While the new digital reality has created enormous opportunities, it has also brought new threats and risks, and it is vital that systems, networks and services are resilient and secure. Despite an increasing number of high-profile incidents, many companies have still not woken up to the risks that technology can pose. "If you think the Fourth Industrial Revolution is something you can avoid, then history is against you," says Ian Buffey, a Cyber Leader at Atkins. "It's going to happen. The question is: how do we allow it to happen in a way that is safe?"

Devices, systems and networks are becoming more interconnected, even though many were not designed for that degree of interconnectivity. New computer-based "cyber physical" systems that operate physical infrastructure and/or machinery can make assets more vulnerable. "The new digital reality is a highly connected world, and with that comes multiple attack threats," says Mark Fielding-Smith, Digital Rail Director at Atkins. He continues, "Across critical national infrastructure such as railways and air traffic control, we are enabling the change from analogue, decentralised control systems to more digital approaches, with safety-critical systems increasingly connected to non-critical systems."

As systems become more complex, it becomes more difficult to assure that all safety and security aspects have been addressed, and to demonstrate that a system or service is safe and secure from outside attack, adds Ian Glazebrook, one of Atkins' specialists in Safety Critical Software Systems.

And while an attack on a physical asset is often visible, for example from a denial of service perspective, software attacks are much harder to detect and mitigate. "Often you don't know of an intrusion until the system fails, and even then, the system tends not to show what has caused the software failure," says Glazebrook.

But failure creates clear safety, environmental and business risks, with consequential impacts on companies'

reputations, and ultimately their bottom lines. As the dangers of digital disruptions grow and become clearer, regulators and lawmakers have started to take note. Just as the European Union's General Data Protection Regulation will punish companies that lose customers' personal data when it comes into force in 2018, the EU's Network and Information Systems Directive (NISD) addresses outages caused by delivery service failures in critical national infrastructure.

NISD is not the first legislation-backed attempt to address the risk to critical national infrastructure posed by cyber-attacks. The North American Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP) regulations are backed by fines of up to \$1 million per violation, per day. NERC-CIP applies to assets of specified criticality in the US and Canadian Bulk Electricity System. The NERC-CIP regulations have been through a number of iterations, and there are lessons to be learned from their growing pains. Unlike NISD, NERC-CIP allows penalties to be levied for non-compliance with the regulations, regardless of whether an incident has occurred, which has led to criticism that the industry needs to spend significant money on compliance (and evidencing that compliance) – money which would be better spent on improving security.

The concept of resilience is not new, of course, and to a certain extent, building robust digital systems is just another element of resilience. However, one aspect that companies could better manage and control is protection from malicious attack.

"There have been some spectacular examples of cyber attacks recently," Buffey says. "Those against a Ukrainian power system are probably the most high-profile." While it has been widely assumed that Russia was behind the attack, there is no publicly available evidence that this is the case.

"That is one feature of cyber attacks – attribution is very difficult. There are justified fears about cyber warfare and attacks on critical infrastructure. The fact is that we are



Cyber terrorism is our biggest concern. If we have a huge data cut and we cannot get access to connectivity for a period of time we may lose business, that's how serious it is. ”

Anonymous



likely to see more like the Ukraine attacks, which are almost like an alternative to economic sanctions," he adds.

Before the Ukraine attacks, there was a widespread assumption that not only were such attacks not possible, but also that no one would want to perpetrate them.

The WannaCry attack earlier this year, which caused severe disruption to the UK's National Health Service, Germany's rail network, FedEx and a host of others, attacking more than 300,000 computers in 150 countries, highlighted the number of organisations with computers that run out-of-date software or fail to fix vulnerabilities in their systems. It is not just hospitals that are vulnerable – a lot of critical infrastructure has old computer systems, because they were built to last at a time when today's digital connectivity had not been considered. The same goes for military installations and equipment, much of which has been in service for decades.

The key to making national and private infrastructure and networks more secure is to take security concerns into account right from the start.

If security resilience is designed in from the beginning, it is much cheaper and easier – retrofitting is always more expensive and problematic.

"To a certain extent, the technology can be the easy part. We know most of the things that we need to do and putting the right measures in place can make a big difference," Buffy says. "But maintaining it afterwards can be difficult, because cyber awareness is still not always embedded in business culture. There is a real need to change perceptions so that organisations treat it with the importance that it deserves."

In this regard, your workforce is both your greatest asset and your biggest risk. They can highlight when something has gone wrong, but they can also introduce vulnerabilities.

While many products on the market claim to help to improve cyber security, technology on its own is not enough. "We prefer to have a long-term relationship with a client, because quick fixes don't really achieve anything," says Buffy.

However, for companies offering advice in this area, it can be hard to make the case for action. Buffy says, "You are telling people: 'this is something that you've never had to



My main concern is how industry and the supply chain join up in cybersecurity threats, because most governance and structures are designed within individual organisations. ”

Kevin Ives,
Digital Transformation
Director, Arriva Trains

worry about before, but now you do and you'll never be finished.' It is not an attractive sell.

"The fact is, though, that the idea that you will completely prevent attacks has gone. Everyone accepts that. You have to plan for the day when you do get attacked."

One looming danger is the growing complexity of the digital landscape. With some artificial intelligence programmes acting in ways that their creators do not fully understand, and the increasing integration between parts of the economy that have previously been unconnected at the network level, the risks abound.

"It used to be that even for a complex project, one person would be able to understand the potential cyber risk," Buffey says. "Now, when everything is all linked together, no one person can grasp the whole thing. The integration of different systems and the relationship between them is

Where does your company sit on the digital transformation maturity spectrum?



something that most organisations have not yet got their heads around."

"Big infrastructure projects and services are vulnerable to attack due their size and complexity, and because their systems are so widely distributed, with multiple connections resulting in a host of potential access points," Glazebrook says. To totally secure them would be very costly and is often unrealistic. Understanding that an attack will happen therefore means we also need to ensure systems and services are resilient to the impact of an intrusion.

"It is in this area that we are likely to see most innovation," says Fielding-Smith. "A lot of innovation will come in the process of integrating new technology. The smart stuff will be in how we bring it all together."

The need for resilience is where the digital revolution is most obviously limited. "The best way to protect a system is to not connect it

to the network," Fielding-Smith adds, but this is no longer viable. "Failing that, critical infrastructure needs to be simple, so it can be tested to see if it performs as required under all conditions."

One useful tool is simulation, as Atkins has discovered in its work on implementing the European Railway Traffic Management System in Denmark. "We found that as you integrate the railway, drawing upon elements from multiple suppliers, it is essential to have a simulation lab where you can put it all together," says Fielding-Smith. "It can be used to prove cyber security, and if you have a simulation set up as a reference, as you upgrade software you can continue to test for security and probe vulnerabilities offline."



53%

say digital capabilities are 'enhanced' or 'optimised'

Conclusion

The Fourth Industrial Revolution

This report is called Digital Reality because despite what many people think, digital is no longer the technology of the future. It is here now and changing the world in a multitude of ways, some predictable and others completely unforeseen.

The digital reality has also been described as the Fourth Industrial Revolution. Klaus Schwab, founder of the World Economic Forum, is clear about the importance of digitalisation. "We stand on the brink of a technological revolution that will fundamentally alter the way we live, work, and relate to one another," he writes. "In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before."

"The speed of current breakthroughs has no historical precedent," he adds. "When compared with previous industrial revolutions, the Fourth is evolving at an exponential rather than a linear pace. Moreover, it is disrupting almost every industry in every country. And the breadth and depth of these changes herald the transformation of entire systems of production, management, and governance."

Infrastructure is no exception. With more than 20 billion devices set to be connected to the Internet by 2020, many businesses, while aware that there are huge opportunities out there, don't know exactly where to start.

"Digital gives us the opportunity to do the fundamentals of what we do now better, and it also allows us to do new things that people have not yet thought about," says Phil Gruber, Atkins' Global Leader for Digital Asset Management.

The first step is to harness all the

information your company is generating and gain greater insight into your assets and their condition. The next step, which is much more difficult, is to use that data to work out where you can make efficiencies or create new products and services.

Getting the most out of digital requires far more than just buying a whole lot of technology and expecting it to work miracles.

However, coming up with a strategy can be difficult when the pace of change is so rapid in areas ranging from artificial intelligence to 3D printing to autonomous vehicles.

Your organisation will also need to adapt, which will require new skills, new ways of working and new ways of managing. While specialist data skills will be crucial, everyone in your organisation needs to appreciate the value of data to the future health of the enterprise.

One key aspect of digital working will be an increase in collaboration, both within and between different organisations. An under-appreciated prerequisite for this increased interaction and co-operation is trust in digital technology and the data that it generates. But as an increasing array of sensors generates even more data that cannot be analysed in traditional ways, we need to find new methods to interrogate and extract value from it. It also means digital systems must be resilient and secure in a world where data is increasingly the target of attacks.

Do you know how long it will take your organisation to embrace the Fourth Industrial Revolution and become digitally enabled? Atkins can help you on this transformational journey. Please get in touch with our report contributors and subject matter experts to discuss your challenges.

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