International Federation of Consulting Engineers
The Global Voice of Consulting Engineers

/SOW2022
State of the World

Digital disruption and the evolution of the infrastructure sector

The only certainty in life is change

/A FIDIC report

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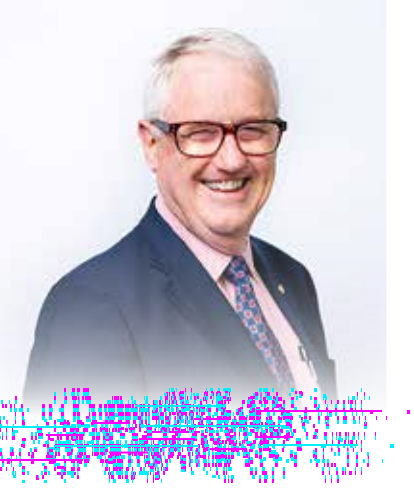

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In 2022, FIDIC continues its resolve in dealing with the significant issues and challenges that face the industry with the publication of this sixth report in the *State of the World* series which was relaunched in 2021.

As the FIDIC president and CEO we are at the forefront of the challenges we face. These are numerous and range from climate change and meeting the sustainable development goals (SDGs), increasing and improving the efficiency of investment, improving the skills and talent pool of the sector and making it attractive to ensure that we can train the next generation of world- leading engineers.

Likewise, the topic of this report is something that not only affects the whole infrastructure sector in terms of our own operations, but also how the sector looks and operates and how infrastructure will be delivered, monitored and maintained in the future. The topic of this report is that of technology and data and digital change.

Technology continues to evolve at an unprecedented pace. Whilst most believe this is a new phenomenon, the pace of technological change and the need for business to invest and maintain a relevant skills base have always been essential.

Having said this, we are both aware that the scale and breadth of technological change and influence in the infrastructure sector will not be addressed in one report.

We start at the macro level asking the big strategic questions. In the future there will definitely be space for additional deep dives into many technological areas of debate including conceptual or feasibility and engineering options, detailed design, 3D / BIM, e-procurement, digital twins, smart contract, drone surveillance/ survey, Block-Chain transaction, assets operations and management, SDG - smart Infrastructure / building / property asset management and ultimate future secondary market of the asset. This was part of the rationale for reforming FIDIC's *State of the World* report series to provide greater frequency and focus where required.

This report explores the pace of this technological change and shows that not only is the pace of change significant, but that many of the technology companies we use today for day-to-day activities in the grand scheme of time are actually very young and company longevity is continuing to decline. This suggests that not only is the pace of change faster, but the companies and people we deal with today may not be the ones we are dealing with in ten years' time.

We also discuss the role of technology as a potential disrupter to industries changing their business model as a result of shifts in technology, data and/or how a combination of how customers/clients and the sector can access and use such information.

It is then also important to look at the role of technology as an innovator and as something which drives real changes and improvements. What does it mean in terms of big data, artificial intelligence, customer lead data and more devolvement of smart devices?

Importantly, we then consider both of the above in terms of how the engineering sector may need to look and operate in years to come.

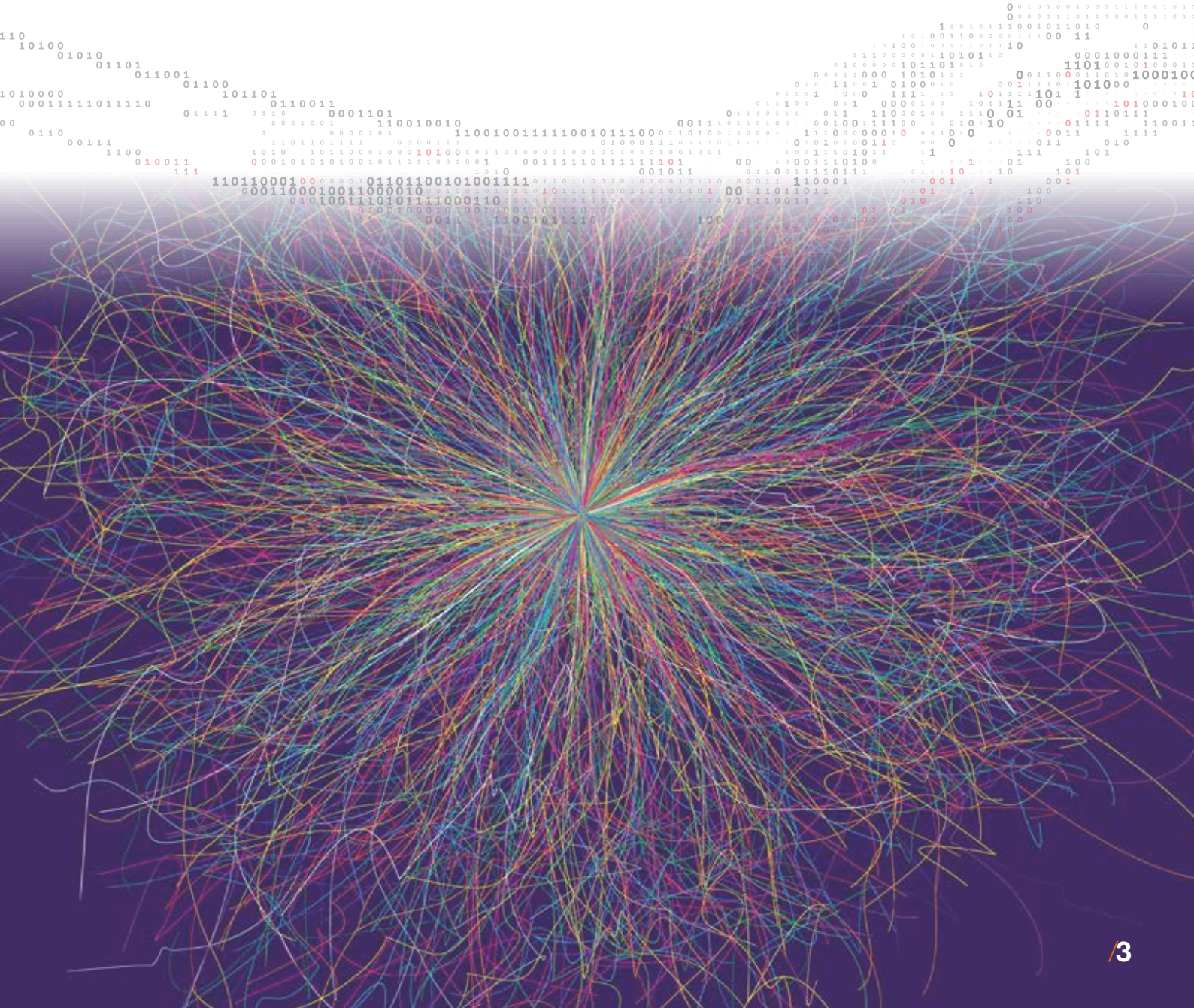
Does the sector embrace data and technology and become one providing a progressive set of solutions with companies becoming full data structured organisations, or are there areas of the sector where disruptors are likely to take hold?

Foreword from the President and CEO

Finally, we consider the role of technology in communication and how this has changed and evolved, as communicating the change of the sector or the sector's vision as it looks to move forward will be vital if we are to attract the best talent.

Change in whatever form it takes will always happen. It is, however, important as a sector that we have open discussions and take a proactive role in deciding how that change occurs to ensure we get the right outcomes for the wider infrastructure sectors, clients and end consumers as we take on the significant challenge of meeting the SDGs and net zero.

This is where FIDIC will continue to play an important role and as president and CEO of FIDIC we intend to ensure this report continues to form a growing bank of evidence and engagement with the widest set of stakeholders in the infrastructure sector to ensure that we can meet the significant challenges ahead of us.



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/Executive summary and recommendations

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Technology continues to evolve at an unprecedented pace. Whilst most believe this is a new phenomenon, the pace of technological change and the need for business to invest and maintain a relevant skills base have always been essential.

To demonstrate this point, let's remind ourselves of what has come to be known as Moore's law, where Gordon E. Moore who postulated that the number of transistors in a given space doubles about every two years. This statement held true until recently where it is believed physical limits have been reached. It does, however, demonstrate that for more than at least 50 years the pace of technology has continued rapidly.

But technology in the digital age is not all hardware. Software is also as vital to phones, tablets, PCs and business process probably more than ever and given the increasing speed of data transmission the reaction time companies and individuals have to respond continues to be squeezed.

This is not, however, the whole story as whilst technology provides multiple opportunities for more efficient working, communication monitoring etc, it also poses several challenges.

As we have seen in recent times with the introduction of GDPR requirements, users are increasingly becoming aware of the data that is being stored on their activity. Authorities are also improving the rights of individuals to access, monitor and if need be, delete such data held on them if so requested. This therefore requires new levels of compliance, governance and risk assessment for companies.

Such data is also valuable, and cybercrime is a direct result of this. Companies are increasingly aware of attempts to try and harvest or illegally access their systems. Such systems therefore now need to be more resilient and secure than ever, whilst also increasingly being integrated and able to share data with other systems both internally and externally. This challenge is not going to subside with the pace of technological change.

This report explores the pace of this technological change and shows that not only is the pace of change significant, but that many of the technology companies we use today for day-to-day activities in the grand scheme of time are actually very young and company longevity is continuing to decline. This suggests that not only is the pace of change faster but the companies and people we deal with today may not be the ones we are dealing with in ten years' time.

Whilst perhaps aiding innovation, the above does provide some challenges when you consider the delivery of items such as the SDGs and net zero where a consistent and high degree of cooperation and innovation will be required. It also, as this report will discusses, creates an environment that is ideal for a disruptor to enter the sector which could change the business model for the consultancy and engineering sector significantly.

It should be stressed, however, that technology and data may not only provide a catalyst for a disruptor but also act as an encouragement for the sector to innovate.

Broadly speaking, the infrastructure, built and natural environment sector at the highest level is facing three outcomes that could take place:

1. The sector embraces data and technology within existing firms but also allows innovation from new entrants where innovative ideas and services improve customer/client outcomes.
2. We continue with the more traditional approach of proprietary data and, whilst there are learnings, the sector is not taking advantage of the sum of its expertise and data and technology.
3. A disruptor enters the market due to insufficient innovation and adaption of technology and potentially reduces the role of engineers within the delivery of infrastructure using its data/ technology assets.

It is therefore important going forward that the sector considers how it wishes to engage in technological change. Broadly speaking, this report discusses three potential approaches:

1. The sector engages with technological change in a similar way to its current situation, where data requirements and technology remain part of a process, but significant shifts are limited.

2. The sector plays a more adaptive approach to technology which is more proactive and will inevitably involve the use of greater data and technology. This could help to drive the sustainability agenda for example by embedding it at the core of all projects and not just as an add-on.

3. The final option is that the sector is progressive. In this respect we consider the sector to be an innovator recognising the significant role of technology and the potential of a disruptor and so going above and beyond to ensure the sector not only plays its role in a data- and technology-driven infrastructure future, but that we are the core driver and innovator of such change.

The above means that companies will also need to consider how they build the above into their own working practices and where they sit on the spectrum between being adaptive and progressive. Below we outline three potential versions of what this could mean for a company.

What kind of organisation are you going to be?

Full data structured organisation – organisations in this position will integrate data, machine learning and importantly the outcomes from data transformation into their activities. You are likely to increasingly resemble a data company than a consultancy company as the data provision between sectors, corporate entities etc, expands

Aiming to be a data structured organisation – these organisations will have gone through the process of understanding what they have and where they need to be. This transition may take time and may involve growing, being acquired or even acquiring the relevant skills, data management techniques or even data access to ensure they can compete going forward.

Extinct structured organisation – these organisations fail to recognise change and the increasing importance of data in day-to-day operations, potentially leading to their cost base being too high and ultimately their business model failing.

Recommendation 1 – Using FIDICs newly established Global Leadership Forum and working with global leader's research should be commissioned on providing a wider and more strategic view of what the sector will look like in five, ten- and 20-years' time. This work should include and consider the technology and data discussions and findings in this report.

Communication and technology

Communication, is it as simple as sending a letter or an email? Not quite. In an increasingly connected and digital age, communication channels and the opportunities and risks that exist are not only in flux but changing faster than ever.

Many individuals are on the internet nowadays. They access the web through their PCs, laptops, tablets and mobile devices. Individuals have a Facebook page, Twitter accounts, LinkedIn and some even have a website and so are no longer communicating via one channel. There are over three billion people on the internet today. As an organisation, it's important to remain current on technology or face being obsolete. Keeping ahead of technology is a necessity if your organisation wishes to achieve long-term stability and growth.

To have access to technology we need to have access to information, to be able to find it as fast as possible, to communicate between each other and exchange information. All types of organisations must introduce digital workplace strategies capable of improving collaboration and communication and enabling personnel to work together effectively, regardless of location or device. Communications are enabling:

- Closer to real-time information being shared in crisis.
- Staff communicating on channels that are outside the traditional 'company technology environment'.
- Reputation reward and risks on such channels are very real.

As such, companies are increasingly finding that simply choosing not to engage is no longer an option and in fact strategies need to be put in place to proactively engage to ensure such risks and rewards are managed.

Recommendation 2 – FIDIC should develop a template to aid its member associations (MAs) and engineering firms to put in place structures which help them manage their social media and communications. Providing templates for both internal and external strategies.

This report has shown that the challenges and opportunities from changes in technological solutions and data are not only here now but will continue to be around going forward and that the pace of change and even the players in the market could change significantly.

Recommendation 3 – FIDIC should establish a long-term Digital Committee to monitor and aid the sector in meeting the challenges of meeting the SDGs and net zero in the light of the technological and data changes that will need to be embraced and progressively and proactively embedded into everyday operations and designs.

Finally, this report has noted the speed of change and with the formation of FIDICs Digital Transformation Committee it is important that FIDIC itself looks at how technology will change its own business model and contracts.

Recommendation 4 – the new Digital Transformation Committee should create a task group to deliver a digital version for all FIDIC contracts by working with industry partners and education establishments.

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/Technological change continues at pace

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/Technological change continues at pace

Technology continues to evolve at an unprecedented pace. Whilst most believe this is a new phenomenon, the pace of technological change and the need for business to invest and maintain a relevant skills base have always been essential.

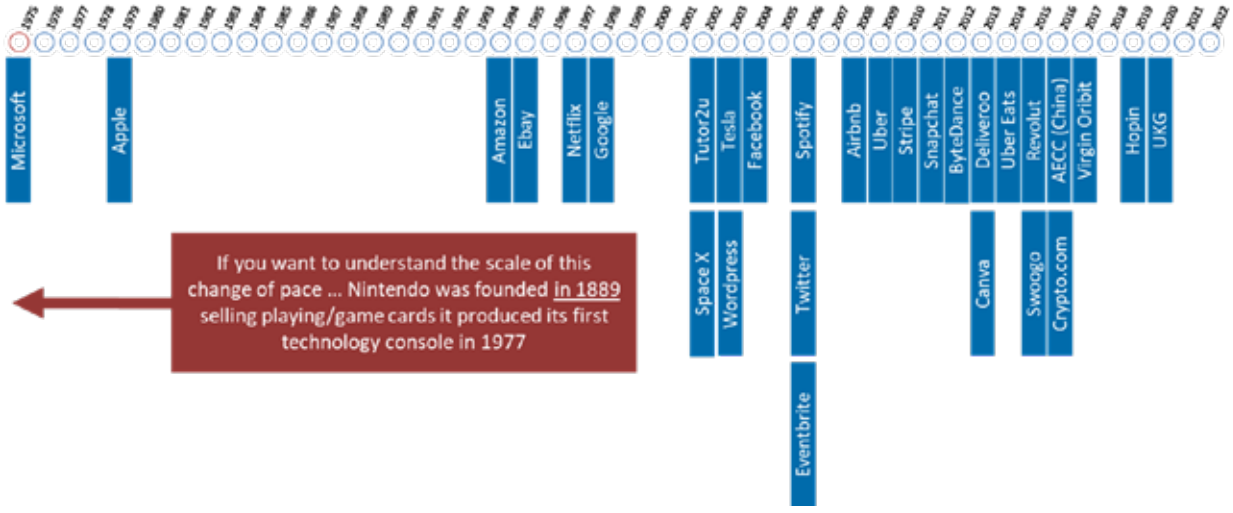
To demonstrate this point, let's remind ourselves of a few circumstances that highlight such change. The first is what has come to be known as Moore's law, where Gordon E. Moore who postulated that the number of transistors in a given space doubles about every two years. This statement held true until recently where it is believed physical limits have been reached. It does, however, demonstrate that for more than at least 50 years the pace of technology has continued at pace.

The second and more recent event is that of the Covid pandemic. It could be argued that at no point in history has there been such a significant shift in working patterns, with the use of online technology for work and socialising and the fast-tracking of research and development to develop new vaccines.

To demonstrate this, the chart below uses desk research to plot the founding dates of some of the most notable and widely used technology services that are still in use since 1975.

As can be seen below, many of the services we use today are products of the 1990s and 2000s, which compared to other sectors such as car manufacturing, makes the market players relatively young. It should be said that there was one notable significant and exception that was found when undertaking the desk research and that was Nintendo, which for many today is considered a technology company, but was founded in 1889 selling playing/games cards and so it could be argued did not truly become a technology company until it produced its first console in 1977.

Examples from technology companies – founding dates



Source: Business Insider, Google, individual company websites

The above, however, whilst not just limited to the technology sector has likely been significantly influenced by their growth. Data from Statista[i] shows that in 2020, the average lifespan of a company on Standard and Poor's 500 Index was just over 21 years, compared with 32 years in 1965. They conclude that

- "*There is a clear long-term trend of declining corporate longevity with regards to companies on the S&P 500 Index, with this expected to fall even further throughout the 2020s.*"

Further analysis of the data from Innosight further corroborates the above with an article by S. Patrick Viguerie, Ned Calder, and Brian Hindo[ii] stating that:

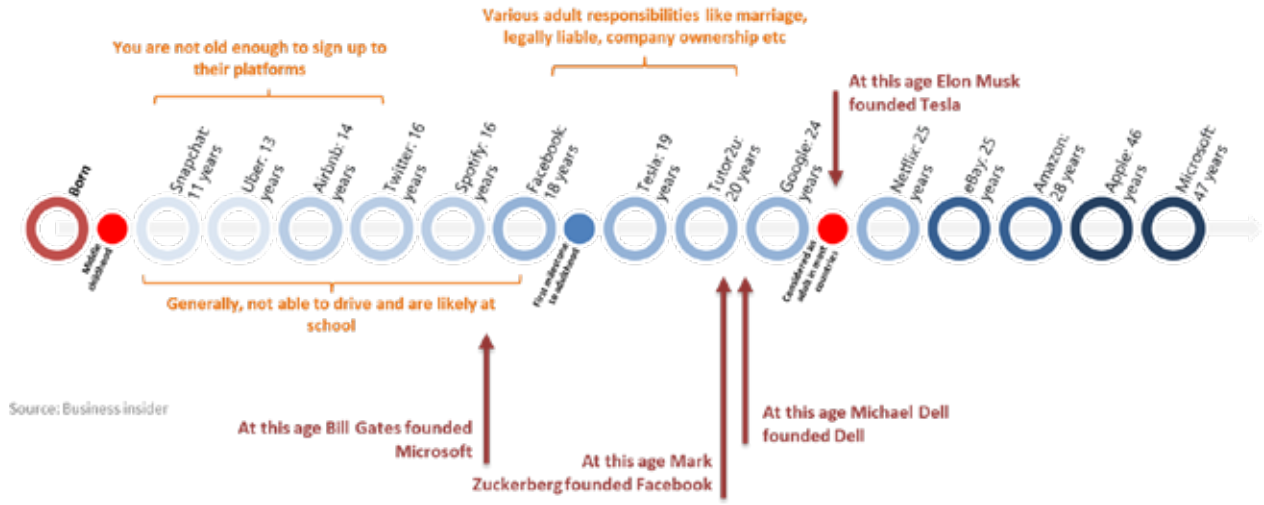
- "*As a long-term trend, the digital revolution has already reshaped the S&P 500. In 1969, industrial companies represented a third of the index. A half-century later, 68 firms are industrials. Over the same span, info-tech companies went from 16 to 68, tied for the top spot.*"

/Technological change continues at pace

The above demonstrates that whilst the past few years may have caused a significant shift in the use of technology due to pandemic conditions, technological change and the growth in its use for increasing amounts of everyday activities has been occurring for a long time.

The infrastructure built and natural environment sector is not immune from such a change in pace, as technological change affects not only the way we build and monitor infrastructure but is also increasingly attracting investment which could otherwise be targeted towards infrastructure and meeting the SDGs.

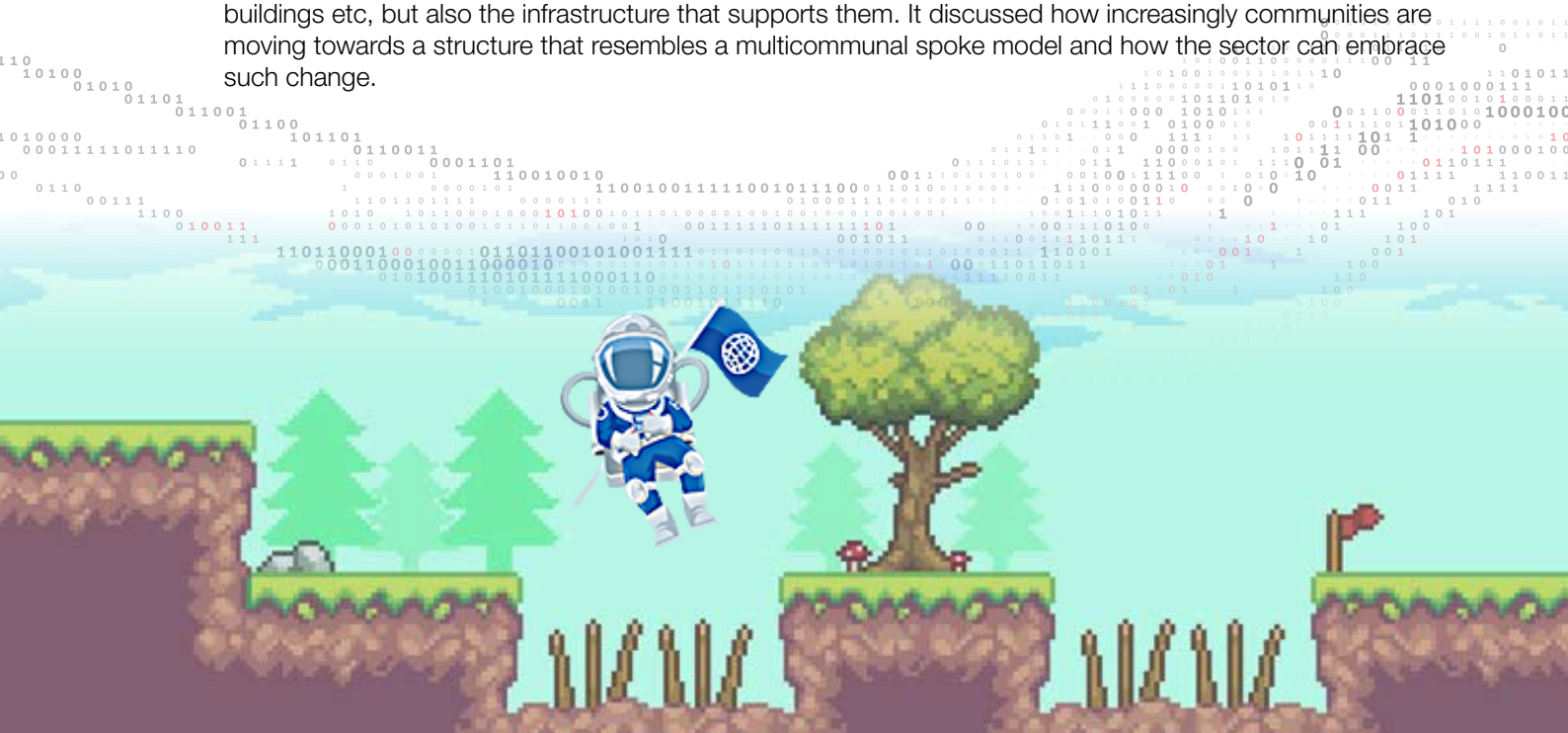
Alternatively, if you were to look at the above from another angle and plot the age of the companies, the age at which some of the more notable individuals founded the companies and consider what they could do if they were a person of that age, it does demonstrate how fast the technology sector has grown into all aspects of life.



Source: Business insider, Google, individual company websites

The above is linked not only to technological progress itself but also to how consumer appetite for technology and its use also continue to change. If you consider the number of devices connected to the internet, Statista[iii] it is found that the number of internet of things (IoT) devices worldwide is forecast to almost triple from 8.74 billion in 2020 to more than 25.4 billion IoT devices in 2030.

This goes to show the significant growth in everyday life with an increasing number of items connected to the internet. FIDIC's *State of the World Building sustainable communities in a post-Covid world* report [iv] discussed spheres of influence and the increasing role of technology, not only in the development of communities, buildings etc, but also the infrastructure that supports them. It discussed how increasingly communities are moving towards a structure that resembles a multicommunal spoke model and how the sector can embrace such change.



Technology is important to customers, but it requires and is reliant on infrastructure

Technology, as we will discuss further in this report, is one of the drivers affecting this shift. For example, it is estimated that the worldwide smart home market will be worth $99.41bn in 2021, with over 258 million smart homes.[v]

This change towards a smarter and more technology-driven way of living and working is happening across a wide variety of products and services. Let's consider for a moment some of the devices that can be purchased by consumers and/or businesses that could be used to make a home's/building and or services smarter. For example:

- Smart light switches and sockets
- GPS and phone monitoring
- Smart bulbs
- Robot vacuums, floor cleaners, window cleaners, guttering etc
- Online notifications for maintenance activities – insurances, boilers, cars etc
- Smart insurance and vehicle statistics
- Smart speakers
- Smart heating and water controls
- Smart meters

All the above to some extent will either interact with existing infrastructure to some degree. This may vary from a device that purely requires an electricity supply to one that utilises and monitors not only its own use of energy but also services such as water, gas and electricity and can be controlled over the internet.

The above started by framing the debate looking at the speed of change and relating this to consumers and ultimately what they are demanding, but as the above example demonstrates, the purchase and use of the devices and the way we live is reliant on the infrastructure around us which enables such services to exist.

These infrastructure sectors are also changing and continue to be affected by technological progress and the influence of new technology players.

This report will now consider at a high level a few sectors where change is noticeable and the impact going forward is likely to be significant, not only for how people live but also for businesses and policy makers and meeting the SDGs.

The energy sectors

The energy sector continues to evolve and change due to technological change. Broadly speaking there are two sides of the market we could consider - the supply side (which is upstream production transportation etc) and the demand side (which is consumers/businesses etc). Technology is affecting both aspects of the market. In the supply side:

- Energy production is shifting towards renewables which is partly driven by technology, cost and the requirement to meet the SDGs and eventually net zero to avoid the significant consequences due to climate change.
- Increasingly, technology is being used in the form of sensors, data analytics and AI systems to forecast and prevent supply failures and to undertake remote maintenance.
- Renewables and technology now require power grids to be more adaptive with distributed generation and supply.
- The mixing and use of hydrogen and the technology to cleanly produce green hydrogen to use in gas systems or as a replacement is being explored to reduce carbon emissions.
- Battery and storage solutions are improving to help and manage peak and off-peak demand and the variability of some renewable's supplies.
- Live data on demand is increasingly available to suppliers via devices on the demand side to enable companies to adjust in supply conditions.

Looking at the demand side:

- There is the increasing use of energy monitoring within supplies and devices, thus giving customers more control over consumption.
- There continues to be interest in devices using lower energy levels, driven by improved customer information, policy and energy prices.
- Customers are increasingly becoming aware of the role of renewables within their supplies as awareness increases about the climate challenge we face.
- The internet of things is enabling the remote operation of devices to minimise and use less energy whilst also improving user experience.

The transport sectors

The transport sector is possibly one of the greatest challenges, but also the sector that could generate significant change because of technology. Let's consider a few examples.

If you consider the rise of apps such as Uber in the taxi sector, there was a market which was considered

unlikely to change but shifted significantly in a short period. Customers very quickly had access to software which enabled them to book, pay, monitor, rate and be located, in a cost, service and price efficient manner.

On the other end of the scale, consider the rise of autonomous vehicles which are currently in development by several companies and range from cars, taxis, vans, lorries etc. Such vehicles would not only potentially change the model of car ownership or car finance towards something more akin to Uber, but it will also potentially mean substantive changes to how transport and roads are financed and funded.

As the above examples demonstrate, there is a significant potential for technology in this sector going forward. Further examples include:

- Technology to make green hydrogen for use in aviation and haulage to reduce carbon emissions.
- The development of improved batteries to enable longer range and more affordable electric vehicles.
- The development of smart charging infrastructure – fast, wireless, recover energy etc.
- Technology to prevent accidents or drive vehicles autonomously.
- Apps to monitor driving performance.
- The use of mobile phone data and commuting trends to model behaviour, supply and demand to get the most efficient outcome out of infrastructure.
- Lighter materials to enable more efficient cars, planes trains etc.
- The use of lidar and various technologies to plan, monitor and remotely survey infrastructure.
- The use of biometric and/or facial recognition to reduce queue times in airports
- The use of apps and mobile phones to not only allow the efficient purchasing of ticket but reduce the need for paper and local systems.

The broadband/mobile sector

Increasingly across the globe, the broadband and mobile sector is being seen as a necessity as computers, phones, tablets and various devices are all connected. The Covid crisis demonstrated not only the need for such services to keep people connected in socially distanced or restricted movement environments, but also the resilience and extent to which business can utilise remote working.

/Technological change continues at pace

As with every sector the broadband sector is also going through its own technological revolution. For example:

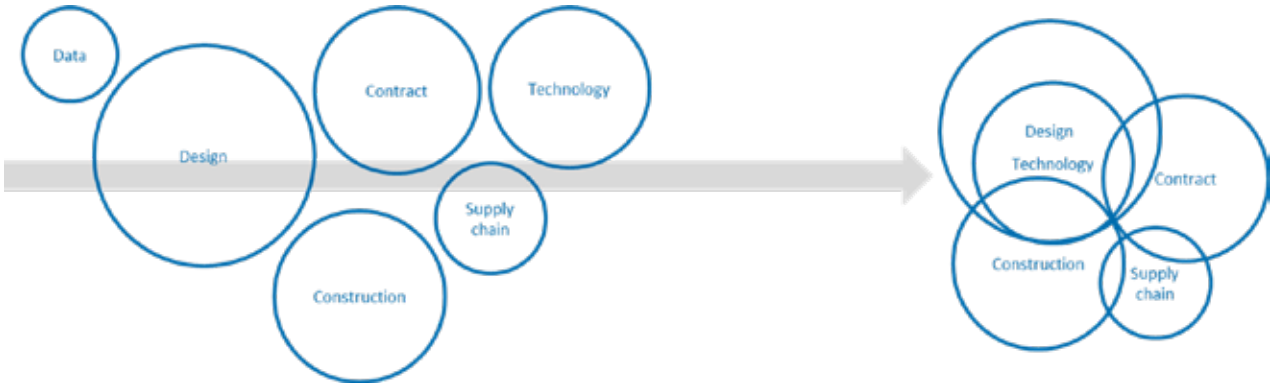
- Internet services are now being delivered via satellite, micro-satellites and even high-altitude balloons enabling access in what would otherwise be remote areas. For example, Starlink has recently kept services connected in the Ukraine despite the ongoing conflict.[vi]
- 5G rollout continues but the sector is already working on 6G technology which aims to be 1,000 times faster than 5G.[vii]
- Broadband potential also continues to increase with researchers in Japan's National Institute of Information and Communications Technology in 2021 setting a new world record for the world's fastest internet speed at 319 Terabytes per second (Tbps).[viii]
- Increasingly broadband services are being linked with other on demand services or additional products. For example, television, music etc.
- Access speeds have reached the point where mass cloud computing for businesses and individuals has become a reality and part of day-to-day activities.

The above demonstrates how complex the infrastructure and technology environment is from end consumers through to the building, operation and maintenance of the infrastructure itself. This is shown graphically in the diagram below as the overlap and interconnection of multiple activities and sectors increase.

Technology is making activities and sectors including the infrastructure sector more integrated

Whilst the above can create significant opportunities, it can also cause challenges. With the pace of change increasing and a greater number of technology companies constituting the largest corporations and corporate longevity decreasing, it will become increasingly challenging to anticipate what the sector, infrastructure and/or technologies will be available in five, ten- or 20-years' time.

This also is important when considering how the consultancy and engineering sector will look going forward.



For example:

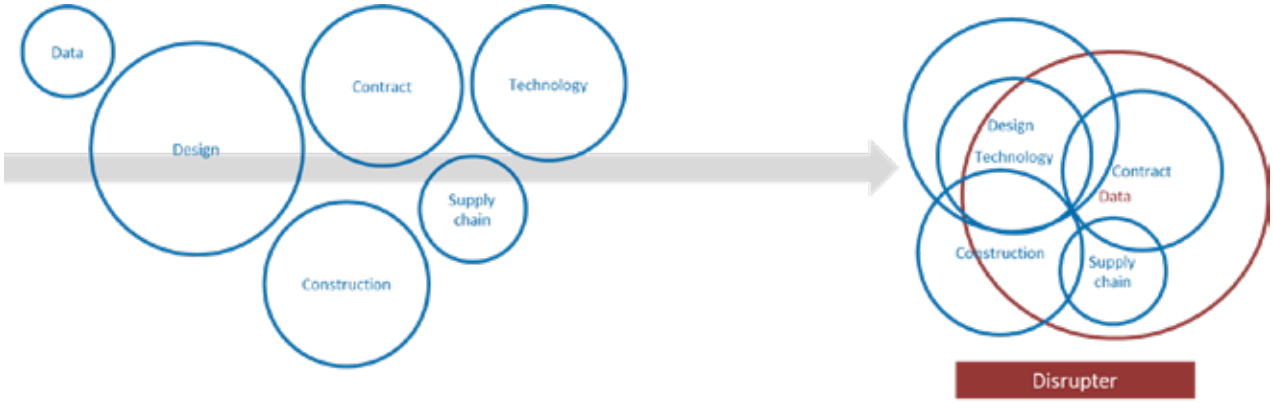
- Will the main players in the sector be the main players tomorrow?
- Are there smaller companies that replace them?
- Given that corporate longevity is decreasing, do tomorrow's engineering firms exist yet?
- What role will technology play in design going forward?
- Will the next competitor to the engineering sector even be from what is traditionally considered a consultancy and/or engineering firm?

/Technological change continues at pace

To understand this further there is a simple amendment that can be made to the above diagram but could potentially change an industry significantly. Let's for a moment theoretically consider that a disrupter or challenger enters the industry, which for example could be a technology company that collects, and controls significant amounts of user data related to infrastructure - what would this mean?

As can be seen given the increasingly integrated nature of the sector, the effect would be significant and have far-reaching implications.

Technology is making activities and sectors including the infrastructure sector more integrated – disrupter



Having said the above, that does not mean that the resultant outcome of a disrupter cannot be positive or that if the infrastructure sector continues to innovate it cannot be ahead of such technological and commercial challenge.

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/Where would a disruptor come from, and would it be purely technological?

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Where would a disruptor come from, and would it be purely technological?

The threat of sectorial disruptors does not prevent the political, economic and environment of a sector slowing down. In fact, sometimes the issue is the opposite as a sector struggle to respond fast enough. Given its wide remit, the infrastructure sector therefore has a significant possibility of such disruptors taking hold.

There are increasingly calls for the procurement and delivery of infrastructure to account for digital solutions, big data, connectivity, AI, sustainability, off-site manufacturing, economic benefits etc to improve efficiency and to deliver more for less.

Alongside this, there is an increasing global movement, particularly amongst the younger generations to focus on the need for not just action on climate change but radical action which could change the emphasis for investment going forward.

All generations are also increasingly being provided information on their impact within society. Today people measure their heart rate, food intake, carbon footprint etc in greater numbers than ever before. The measurement of such statistics used to be reserved for only large environmentally focused projects.

This has also created a shift in global politics, placing pressure on long-established global institutions to change whilst also polarising politics within countries. The ironic result of these political pressures is that whilst there are various impetuses to act, the environment for investment feels increasingly less stable, so increasing the risk premium.

A disruptive innovation is an innovation that creates a new market and value network or significantly alters the business model so disrupting an existing market, displacing established market-leading firms, products, and alliances. These changes are increasingly becoming digital in nature with new digital technologies and business models changing the value proposition of existing goods and services.

Given the growth in the digital sector within the top global corporations, the increasing integration of infrastructure delivery and use, it is fair to consider that the potential for a disrupter to the infrastructure sector which emanates from the digital space is increasingly likely.

How disruptive can technological change or a disruption be?

In short, and significantly, a good example of this was the photography sector. One piece of technology evolved (the digital camera), which on the face of it made photography simpler for consumers. This innovation fundamentally altered the Kodak business model and led to a significant change in how they had to operate and who they were competing with. But what could the infrastructure sector learn to either prevent disruption or to speed up innovation to avoid a similar situation?.

What would be some of the warning signs of potential disruptors for the sector?

- **Venture capitalists are increasingly interested** in companies related to the sector – this shows there are new opportunities which traditional incumbents are missing.
- **Technology is used to cut costs** rather than to improve or innovate customer experiences – this can put significant strain on existing companies with high sunk costs.
- **The industry has an aging customer base** with few new customers – making the effects of any disruptor more pronounced.
- **The industry uses hands-on customer service with few digital touch-points** – this not only makes the cost of adaption to new digital technology harder for incumbents, but it also gives the early innovators of new technology an edge which can be hard to replicate.
- **Customer satisfaction is low** in the industry and or customer experiences are frustrated by market frictions and overly complex manual processes.

Where would a disruptor come from, and would it be purely technological?

What could potential disruption in the infrastructure sector look like?

Harmonisation vs standardisation – with increasing use of open data and API exchanges, harmonisation of such information structures allows for innovation but does not go as far as to impose operating structures/ systems onto market participants. Standardisation can achieve similar goals, but it takes time to accept/ develop standards against an increasing pace of change.

Understanding or use of technology and approach – the approach to the use of technology differs across various departments/regions/nations/sectors based on many factors including, maturity, access to the internet, regulations, interconnectivity etc.

The app/mobile concept… and drones of course – there are an increasing number of portable and digital devices that can measure more parameters than ever before. These are devices are travelling around and consumers are happy to use them! This has created opportunities to connect to customers but also for measuring and monitoring the efficiency and quality of infrastructure, building etc. These devices are literally all around us.

Joint R&D – companies are increasingly working together to develop baseline common technologies. A good example of this is the automotive sector where R&D is used across multiple cars makes and models, such as the next generations of batteries and automated driving solutions. This demonstrates not only the evolution of an industry reacting to a digital disruption (Uber/Grab etc) but innovating to stay relevant within an evolving sector. What next? What does this mean for the way we invest in roads e.g. Do we need smart motorways? Could automated cars monitor road conditions?

AI, Big data, the internet of things and BIM – there is an increasing trend not only to collect data but also using it intelligently with AI. Only this month (September) Daniel Dines Of $7bn UiPath Became the First Bot Billionaire, automating repetitive tasks for clients. A combination of BIM, Data from various projects experiences, sustainability and environmental requirements, automation of simpler tasks and the development of client facing tools will increasingly integrate technology into solutions.

Changing consumer needs – the breath and scope of changing consumer needs means that any engagement to understand changes needs to cover a wider variety of stakeholders. Clients will demand infrastructure of a certain form, but this does not mean that end user habits are changing at the same pace, and these will affect future projects. For example, mobile subscribers overtook fixed line subscribers in 2002, so looking ahead 5G has the potential to see mobile data usage overtake fixed line data usage.

Digital security and personal data – this are increasingly important not only to end consumers but also to corporates where digital breaches represent a significant and systemic risk to the business and its legal/ regulatory operations.

Where would a disruptor come from, and would it be purely technological?

Digital skills – implementing technology requires having skilled individuals that are consistently keeping their skills up to date to evolve with technological trends. Keeping such skills or suppliers is becoming a vital need for companies as the market develops.

Staff/internal skills – new technology itself causes skill issues. To upskill, train and develop existing staff to new systems is not a small undertaking in most companies.

Client/external skills – sometimes it is easy to forget that there is someone sitting on the other side of your systems who also must be trained or have the knowledge to interact with you effectively.

Controlled approach to thinking 'outside the box' – Alphabet (Google parent company) owns more than 200 companies and has a division focused towards acquiring and or developing new initiatives where technology can be applied known as Moonshots. Everything from Nest to NHS data and AI go through such explorations. Google may not compete with you to build a hospital, but it may soon be telling you how best to run it and who should be treated in it.

Example how a disrupter can change the whole approach of a sector

To help demonstrate the above, let's consider the roll out of smart motorways which have taken place in many countries. Broadly speaking when implemented the options were:

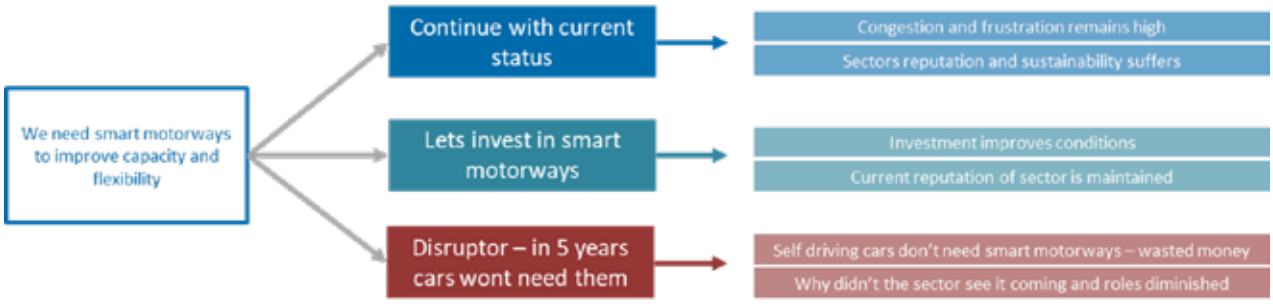
1. Continue with current status – costs of traffic, congestions etc.
2. Invest in smart motorways – improve journey times, safety etc.
3. Disrupter – on horizon but a threat.

So, thinking about the first of these options, politically and socially this is difficult to justify if the investment brings economic and welfare gains, which is the basis on which many infrastructure investments take place.

Option 2 is one which would be widely regarded as positive as it sees investments in the network and improvements in journey times etc. but within this there are a whole host of variables. Are you investing in full-on smart networks that are automated and have significant technological infrastructure, or are you taking a cheaper and lighter route where the technology is there but to a minimal level? It is the bandwidth of the decision within this category that causes the most debate as it can ultimately result in projects being perceived as a success or failure. For example, in the UK the smart motorways programme has been frozen until five full years' worth of safety data has been collected.[ix]

Option 3 currently is a theoretical but important question. Self-driving cars have already clocked up millions of miles in tests in motorway and city environments in existing roads and whilst these improvements continue to take place and as mobile speeds with the introduction of 5G allow them to communicate faster, the need for smart motorways may become irrelevant not long in lifecycle terms of their eventual roll out.

This example demonstrates the issue is not just one of a single company as a disrupter (which could also be the case if a market leader were to emerge) but also one of technology making current solutions redundant even faster than before thus disrupting current assumptions and investment models.



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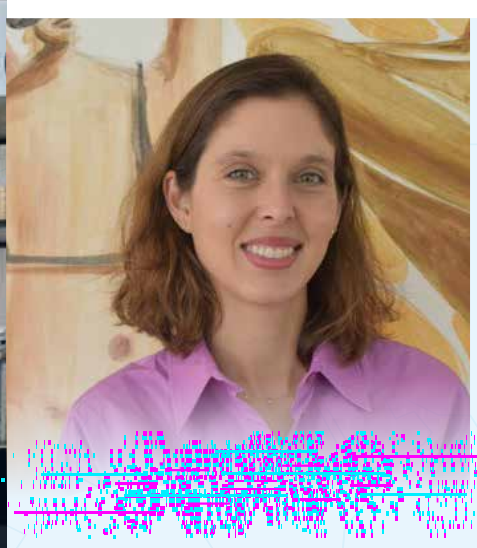

Laura Recena
Head of Marketing and Communications
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Covid 19 was a disruptor and shifted the sector towards digital collaboration and the future of work.

The covid-19 pandemic significantly impacted corporate communication channels all over the world. Employees' digital experience was already a priority in some sectors, such as technology - an early adopter of hybrid and remote working configurations. We can't say our market was as prepared as tech to face distancing measures when Covid-19 struck. Consulting engineering companies that already had implemented business communication platforms and digital collaboration policies faced a much smoother transition to home office than counterparts who didn't – the majority, unfortunately. Now restrictions are being lifted, and offices are gradually being reoccupied. Some may conceive that the competitive advantage of mastering the online environment will lose momentum. But this might not be the case.

The need to invest in digital collaboration tools was not new when the pandemic began, but Covid-19 certainly made it more urgent. Even when the world had not yet embraced home office, the urge for tools to facilitate collaboration between colleagues was already expressed by workers. In 2013, Deloitte surveyed 3.600 employees of European companies to assess their take on digital collaboration. The research resulted in a report called Digital collaboration: Delivering innovation, productivity and happiness. It pointed out

that employees' satisfaction is considerably higher when the workplace culture offers collaboration tools to enable «richer communication, document sharing and co-creation».

When remote working was a distant reality to most companies, digital collaboration was already relevant to talent retention. Now it seems imperative to have tools that enable cooperation within and outside the physical office. Research suggests that, while controversial, remote work is popular with employees. According to a report published on November 2021 by Qualtrics, «Hybrid work is here to stay, and employees have high expectations for in-office and remote work experiences». Ernst & Young's Work Reimagined Employee Survey 2021, which gathered information among 16,000 respondents across 16 countries, confirms the trend: lack of flexibility could drive 54% of the workforce to quit.

In this scenario, digital communication platforms aren't just a competitive advantage. They are necessary for companies who wish to compete for talent – crucial for service companies like ours. But digital collaboration platforms aren't the solution alone. Recent research by Microsoft shows that remote work environments tend to cause «the collaboration network to become more heavily siloed». The reason is less spontaneous transversal contact among people from different teams. So, in addition to the ICT solution, it is also crucial to have a cohesive Communication & HR strategy to incite the desired interactions in the digital workplace. Managers must make sure each one on their teams understands what must be done, how and when. Strengthening weak ties – relationships between colleagues who don't interact much - is crucial for the cohesion and continuity of a company's culture and managing knowledge.

At TPF Engenharia, we were fortunate to adopt a digital collaboration platform before the pandemic began. Its integration with a document management solution made collaboration straightforward in the remote working configuration. Our virtual environment facilitates the sharing and editing of documents, the management of virtual teams, and the synchronous and asynchronous management of information. We promote virtual events, both technical and informal ones - to promote social interaction. The combination between our tools and policies has given us encouraging results. Proof of that is our 20% growth in revenue in the last 2 years.

Key take-aways

- Employees have placed flexibility as one of the most relevant aspects of work.
- Digital collaboration tools must be accompanied by a strategy regarding how they must be used.
- Managers should keep close contact with teams.
- When your workforce is dispersed, additional attention to cohesion (strengthening weak ties) is needed.
- The company must create opportunities for informal interactions between members of different teams.

There are situations where physical presence will always be necessary, as with supervisory services. Also, we must not forget that some people still prefer to work full-time in the office. The key is not to have one rule that fits all. The path TPF Engenharia has chosen is doing its best to offer our workforce the flexibility they desire to have whenever possible. For this reason, investments to make collaboration smooth, easy and vibrant in the digital environment are strategic to us. Although we live in particularly uncertain times, we believe «the near future» requires the capacity to embrace hybrid. Those who have not addressed the importance of investing in communication won't be prepared and will likely face recruitment and productivity problems.

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/Technology and digitalisation as an innovator

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/Technology and digitalisation as an innovator

Digitalisation has become a word that is used more than ever, sometimes as the solution of everything. But how do we value digitalisation in a long- or short-time perspective? If we look back, it's easy to see innovations that we would not have thought possible if we asked a few decades ago. We also see products that were then considered technological breakthroughs that today is useless trash laying around in your home. All a witness of rapid change. All a witness of 'innovate fast, fail fast'.

We know today that one of the biggest risks in investing in new technology is the risk of it being worthless before we even have time to get any return of our investment. At the same time, we know that without investment we risk being wiped off the market.

In this context, engineering services firms must navigate and be the best provider of financial and technical advice to their customer. To tell what way to go and what way to avoid. To analyse technical solutions and possible technical development and navigate this through local regulations and long-term demands in delivering on all aspects of sustainability ecological, social as well as economical.

So, the question is. How can and will digitalisation affect what we deliver and how we deliver?

Fourth Industrial Revolution (4IR) applications for the infrastructure sector

The field of 4IR applications in wastewater treatment is extremely exciting! Instead of fearing 4IR and the loss of jobs, 4IR should be welcomed. It will assist us in coping with the dynamic responses required in dealing with climate change, as well as attaining the requirements of the SDGs.

Big data

Being able to process large amounts of data is essential to the optimised operation of water infrastructure. In the world of 4IR, the management of data has made it easier to use big data solutions, deep learning, machine learning, artificial Intelligence, business analytics and the internet of things.

In water-scarce countries, digitalisation will not only allow us to reduce water consumption and losses, but it will fast-track sustainable and resilient design of infrastructure.

To measure is to know, and having online measurement of anything from flow data, chemical and energy usage, or anything at all really, will allow utilities to optimise both consumption of energy and chemicals. Through the internet of things, every point in the system (water source, water treatment, water distribution network, wastewater collection system and wastewater treatment/reclamation) can be monitored regardless of how remote the system is. For example, through understanding usage patterns, utilities can use predictive analytics (and artificial intelligence) to ensure no taps run dry while optimising opportunities to pump during cheaper timeslots.

Furthermore, it will enable predictive maintenance and massively reduce the cost currently associated with "run-to-failure" maintenance caused by onerous procurement procedures experienced by some utilities. It will also enhance your confidence of the reliability of your assets through dynamic asset management.

The power of dashboarding

Although dashboarding is nothing new to the water industry. business analytics comes into its own when it comes to the control of wastewater treatment processes. Being able to process large amounts of data will enable business analytics to convert any data to helpful and graphical information via dashboarding. Thus, depending on what your role in the organisation is, you can view any volume of information in the form of graphs, graphics, distributions etc. allowing for a big- picture view of the health of all activities. Should a problem be identified, an individual can then drill down and interpret data down to the most detailed aspect of a single process or piece of equipment.

It is possible, therefore, to dashboard various useful outputs and processes such as:

- the flow and load entering multiple works compared with the capacity of the works.
- allowable treatment capacity to ensure that plants are obeying regulatory and/or legal standards.
- predictions on when peak flow events will enter the plant, based on sensors in the network.

- maintenance requirements based on monitoring the performance of assets over time and predicting the best time for intervention.
- track the requirements for your process controllers/operators to improve their qualifications, skills and experience; and
- load all site-specific information (such as site-specific reports, design reports, as- built drawings, geotechnical reports) to all be viewed in one place without the need to undertake manual processes such as looking through O&M manuals when you need to troubleshoot a process unit.

From a process point of view, the above is very important as it allows companies to be able to view in real time any changes in parameters with pre-set limits to alert you to problems and or to take pre-emptive actions to ensure the most efficient operations.

For example, this means that instead of losing your organisms in your process tank during an industrial dump event or storm event, companies can have an early detection system alerting you to divert the incoming flow, if possible.

It enables companies to optimise their chemical addition to the changes in flow and load, ensuring that you do not dump too much disinfectant in the receiving water body, or use too much metal addition, reducing your options of beneficiation of your sludge.

This data can also be used by designers of treatment works to improve overall lifecycle costs in the design of new works. It can obviously also assist in ensuring that chemicals are ordered timeously and chemicals where efficacy may reduce over time are not ordered in excessive quantities.

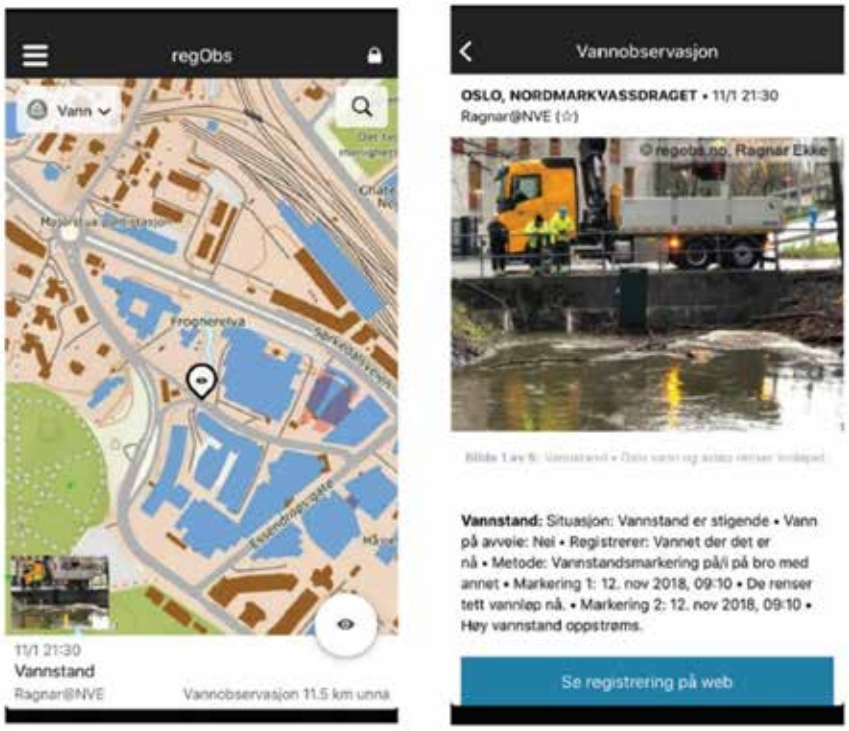
Crowdsourcing tools to give the public/asset owners information and early warnings in crisis

Early warning systems are an important component of disaster risk management strategies. In contrast to flood forecasting systems, which assess flood risk, the main purpose of early warning systems is to issue warnings when a flood is imminent or already occurring [x].

The early detection of deviations, problems and undesirable incidents is crucial for intervention during floods and other geohazard events. Dam and levee owners and responsible authorities must follow the development of such events from an early stage. Sharing of information is valuable for all involved. By inviting professionals and the public to contribute with observations, the number of observers within safety management increases.

In Norway, a crowd-sourcing tool called regObs, gives the public and dam owners an easy way to report and share relevant observations. It was presented in the 87th Annual Meeting and Symposium of the International Commission on Large Dams [xi]. The tool uses an open data policy, and everybody can register observations as well as see all observations. Observations are georeferenced, and follow a predefined form adapted to the specific topic. Pictures and notes can be added easily to the observations. The observations provide useful information during emergency actions and in the national flood, landslide and avalanche forecast services [xii].

Figure 20: Screenshot of the regObs mobile app for ID168595



Source: regObs mobile app for ID168595. Left: Map with short information about the observation. Right: Filled-in form with a picture [xiii]

These systems can make a major contribution to the safety of cities and infrastructure around the world. Despite technological advances, however, they still face multiple barriers to successful deployment.

- Limited telecommunication networks could reduce flood warning efficiency and distribution, particularly in remote regions of developing countries. These deficiencies often worsen during extreme events.
- The maintenance cost of the systems can be high.
- There is often a diversity of actors: administrations, managers, weather-information providers, technicians, politicians. Liabilities for decision making are high.
- The physical modelling is complex and often involves diverse interacting phenomena such as river, rain or coastal flooding. Specific aspects and local knowledge are relevant and automated systems are often not enough.
- Decision-making requires a minimum early warning time to implement an emergency plan or even evacuation plan, e.g., 3-4 hours.
- Good flow forecasting models are needed, converting rain forecasts into runoff forecasts. But uncertainty needs to be managed for subsequent decision-making.
- Availability of good quality real-time data may be limited.
- The warning carries a degree of uncertainty, which could lead to false alarms.

Cybersecurity continues to be vital

A recent article in the *New England Water Works Journal* [xiv] described a study of cybersecurity systems at 30 utilities in Virginia. It included an overview of an evaluation of cybersecurity risks to these drinking water utilities using ISO 27001, a well-known cybersecurity standard, as a guide.

The assessment findings identified the following cyber-threats to process controls and business systems and implementable solutions (highest risks are in bold and possible prevention and mitigation strategies are bold):

- Information security policies
- Organisation of Information security
- Human resource security (train staff specific to their role and the cyber assets they will be working with)
- Asset management (maintain accurate inventories)
- Access control (password management)
- Cryptography
- Physical and environmental security (especially consider remote sites – provide access on a need-to-know basis)
- Operations security (malware protection (update software, patches etc.)
- Communications security (separate SCADA and business networks, VPNs (virtual private networks or firewalls)
- System acquisition, development and maintenance (maintain an accurate inventory of computer hardware and software and make sure they are fit for purpose)
- Supplier relationships
- Information security aspects of business continuity management and
- Compliance

In addition, a recent article in *OPFLOW*, mentioned that security systems are becoming increasingly intelligent, with more powerful software and greater flexibility. Such technology provides new opportunities for water utilities to upgrade and improve security monitoring.

Technologies such as video analytics and compact radar are providing smarter detection (such as thermal cameras which use heat generated by an object and are not susceptible to shadows), more detailed assessment and more automation, but require less infrastructure. These are especially effective at protecting remote sites. [xv]

The ANSI/AWWA G430 Standard defines the minimum requirements for a protective cybersecurity program for the water sector. [xvi] This article notes that the top five areas of common security gaps in water supply are network configurations, media protection, remote access, documented policies and procedures and trained staff. Establishing a strong cybersecurity environment is the basis for implementing a strong cyber defence. Such a programme should consist of technology, people and physical protection. It is critical that utility managers create and support a cybersecurity culture.

Training

One of the most exciting 4IR applications in the field is around training. By using augmented and virtual reality, you can train both designers and process controllers on the outcomes of decisions without catastrophic circumstances. This also allows the utilities to play around with designs before a new treatment plant is constructed, allowing for absolute fit for purpose design and technology applications.

Safety

Automation and digitisation are also a huge win for safety. For example, companies can use 3D cameras to record and assess assets such as a large pump station wet well, and this gives the designers/engineers/contractors a comprehensive understanding of the asset without the need for confined space entries.

Fifth Industrial Revolution (5IR)

Ultimately, all the exciting things in 4IR will lead to 5IR. There are many definitions out there, but essentially, it means doing the right thing for the environment and the planet. By using the 4IR tools and embracing the eventual move to the 5IR, we can ensure sustainability and optimum use of available resources, ensuring longevity for our children and future generations.

Digitalisation is changing the arena on what we deliver across the infrastructure sector

New technology can create totally new conditions for development. Inventions can make things possible that seemed impossible before. Technological advances might even disrupt a whole industry.

In parts, this is what we see in the digitalisation that society is undergoing. At the same time, it is not the technical solution itself that generates the great benefit or the great value. The commercial value emerges from the user benefit and user experience and the new business model that can capitalise on these commercial values. The digital technology itself can even be an obstacle for value creation if it is dysfunctional, limiting and does not live up to the user's now ever higher demands.

In a society with rapid technological development would, let's say, a monitor that does not have touch functionality be perceived as broken. Would an application that could not easily communicate with another device regarded as useless? The digitalisation that society is undergoing leads to an ever-faster pace in increasing customer requirements.

This sets new demands on the processes in the construction of the physical infrastructure. The question is raised about how we will be able to keep up with the pace at which customer requirements increase. It will put an even higher demand on the ability to adapt to new requirements and to make changes later in the process. Development must become more agile and the ability to adapt to changing requirements must increase. This applies not only to digital development, but it also applies to sustainability requirements and resource management.

Will a digital process innovate how we work?

The answer is YES, and NO. A digital, unbroken, building process has the possibility to create benefits for users, citizens and businesses by including all actors involved in the urban development process. In theory it will be easier for different actors to have contact with each other and to gain access to the same information and decisions and in so doing lead to a faster process and higher quality.

But this is not mainly an issue of technical and digital knowledge, it's also a question of changing culture in a traditional building sector and the acknowledgement of the value of good functionality and quality parameters throughout the process.

Digitalisation can be the enabler, but it all comes down to relationships, cooperation, and contracts between different commercial actors. Not even the best digitalised process can solve the issue of making end customer demands and lifecycle functionality visible, acknowledged and treasured.

The great fortune in this is that a digital process could also help you with this. The possibility to collect and evaluate data is enormous. Also, to use, analyses, simulate and evaluate alternatives based on collected data and earlier projects. Data that will create customer value. This means that even more of the customer value-creating process will emerge from having access to data. And the ability to analyses to help the customer take the right decision.

Having all this at hand, strengthening digital knowledge within any sector is a must. This includes more and better education from early years, not only concerning ICT and programming but also on how to rethink? and evaluate possibilities from a digitalised perspective. We also need a stronger knowledge base on how to value, capitalize and regulate the use of IP.

Engineering service companies are and will be an even stronger driver of change. A change that emphasizes even more the importance of clear contracts and the ability to capitalise on the value of data. Engineering services will continue to be the driver for innovation and sustainable value creation.

/SOW2022

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The use of artificial intelligence in infrastructure projects

Technology and Innovation are concepts not so easy to define. While the first one is commonly known as the application of scientific knowledge to practical situations, the latter has a big sort of definitions, ranging from an improvement in an existing technology (incremental innovation) to creating something new that changes the existing patterns or models (disruptive innovation). Despite the cloudiness of the definition, innovation is being used to fasten and improve quality of infrastructure projects all over the world due to the increasing pressure to create value to the economy and the society.

One of those projects is the *New Ferroeste*, developed in the south region of Brazil. The project aim is to build a railway between the state of *Mato Grosso do Sul*, in the central west of Brazil and the *Paranaguá* Port in the state of Paraná, with the objective of increasing the transport capacity in the region to export mainly the soy and its subproducts cultivated in the middle portion of the country. To accomplish this endeavor, it will be necessary the construction of 1 300 km of railways, crossing two states, to get the cargo to the Brazilian shores. The project is in the phase of technical, economic, environmental, and legal feasibility, in which TPF Engenharia participated, with an execution deadline of one year.

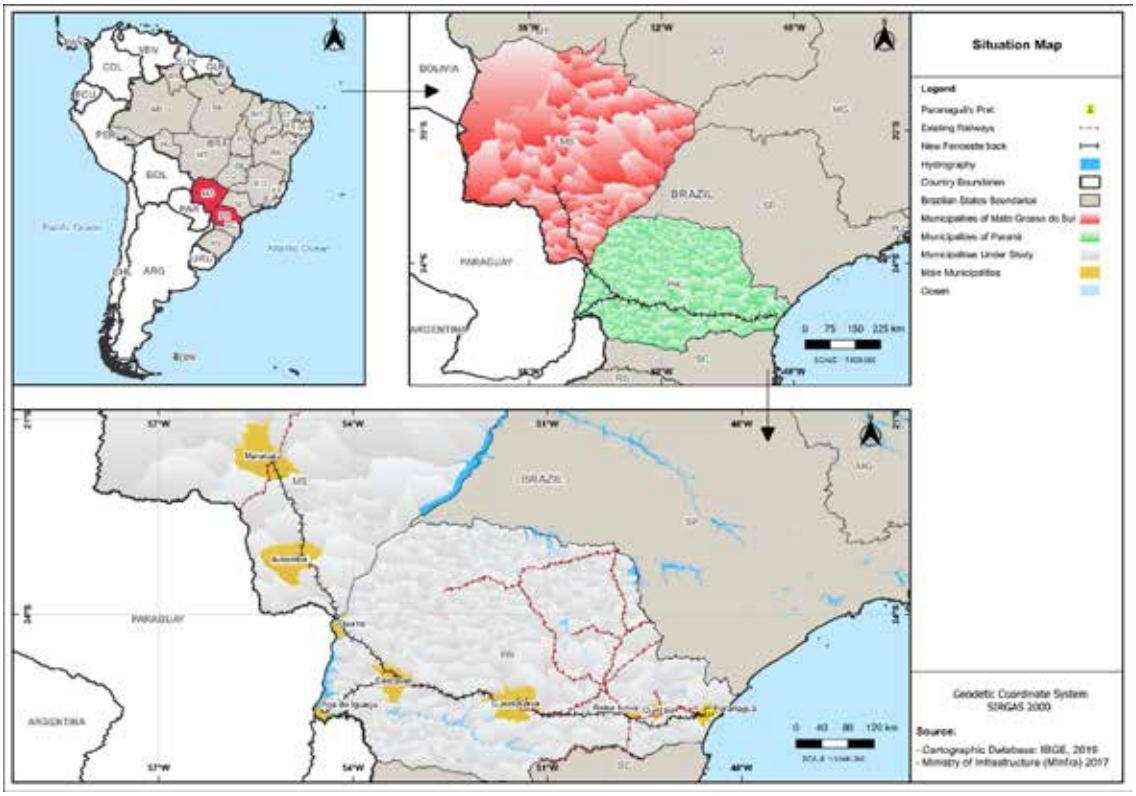

Figure 1 - Situation Map of the New Ferroeste.

Time is always a scarce resource, but in the *New Ferroeste* project, it represented a major challenge to overcome. Imagine conceiving, designing, and modelling 1 300 km of railways, crossing two states with a considerable accidented topography, a high pluviometry index, an extensive list of environmental interferences, such as permanent conservation areas, indigenous conservation areas, and *quilombola* [xvii] areas in only one year. On top of that, to arrive to the *Paranaguá Port*, it was necessary to overcome more than 900 m of unevenness, a formation called *Serra do Mar*, which has an accidented relief that must be adjusted. Due to this global picture, one of the main challenges was to perform the preliminary trace of the railway, which had to cope with all these interferences and obtain the best possible solution to the project. Another key point is that the definition of the preliminary trace will pave the way to all the other studies performed, which means that its quality is fundamental once it may even affect the feasibility of the entire project.

Traditionally, the definition of the preliminary trace is done individually by the specialists in each discipline. So, the process starts normally with the topography, where the engineer decides where the best path for the railway is, according to its experience. Then, the project is passed to the hydrology specialist that will analyze if there are any interferences in the original trace. If so, he will perform the changes and return the project to the first engineer for validation and so on. It continues for all the disciplines involved, including the environmental, becoming iterative, which takes a lot of time, once the definition of the preliminary trace must be consensual between all the specialists involved. Moreover, the trace is usually conditioned to the first one drawn, which eliminates the study of other possibilities that could be as good as the chosen one, or even better.

Due to time restrictions and the big length of the railway, *TPF Engenharia* had to innovate and developed a new way of defining the preliminary trace, once the traditional approach would be very costly in terms of time and effort. The solution was designed in terms of the experience of the specialists, multicriteria analysis and artificial intelligence.

First, the specialists on each discipline did a profound study of the characteristics of the region, such as hydrology, topography, geology, environmental, social, and others. Then, each dimension defined some attributes and gave a grade from 0 to 10, considering its positive or negative impact in the trace of the *New Ferroeste*. For example, in the geotechnical discipline, Soil A was really good for the crossing of the railway and was graded 10, while Soil B was really bad and graded 0. Another example is in the environmental field. The Integral Protection Areas were all graded 0, once crossing it is an environmental crime and other areas where the railway could pass without any problem were graded neutrally, 7, so that it did not influence too much the analysis.

After the grading of the attributes, a multicriteria analysis was performed to determine which disciplines are more relevant to the trace of the *New Ferroeste*. It was done through a methodology called Analytical Hierarchy Process (AHP), presented by Saaty (1977), normally used to decision support in a multivariable scenario. It consists of analyzing the chosen variables two by two and attributing weights of relative importance between them to create a comparison matrix, such as presented in *Figure 2*. For so, the specialists from each discipline gathered in a council to define those weights based on the study previously done.

AHP Matrix				
	Mercadological	Physical Environment	Logistics	Socio-Environmental
Mercadological	1	0,50	2,00	0,60
Physical Environment	2,00	1	2,50	0,80
Logistics	0,50	0,40	1	0,40
Socio-Environmental	1,67	1,25	2,50	1

Figure 2 - Example of an AHP comparison matrix.

With the grading done by the specialists and the multicriteria analysis, the data was inserted in a software of geographical information system (GIS) to process all the information generated and obtain the best traces, called favorability corridors. Due to the huge amount of data and the connection between all the dimensions analyzed, the computational process was done through Artificial Intelligence (AI) to gain velocity and to analyze all variables at once. Then, an AI code was created inside the GIS software to process all the information and then spatialize the favorability corridors, marked from dark green to light yellow, as seen in *Figure 3* so that the engineers could perform the necessary analysis.

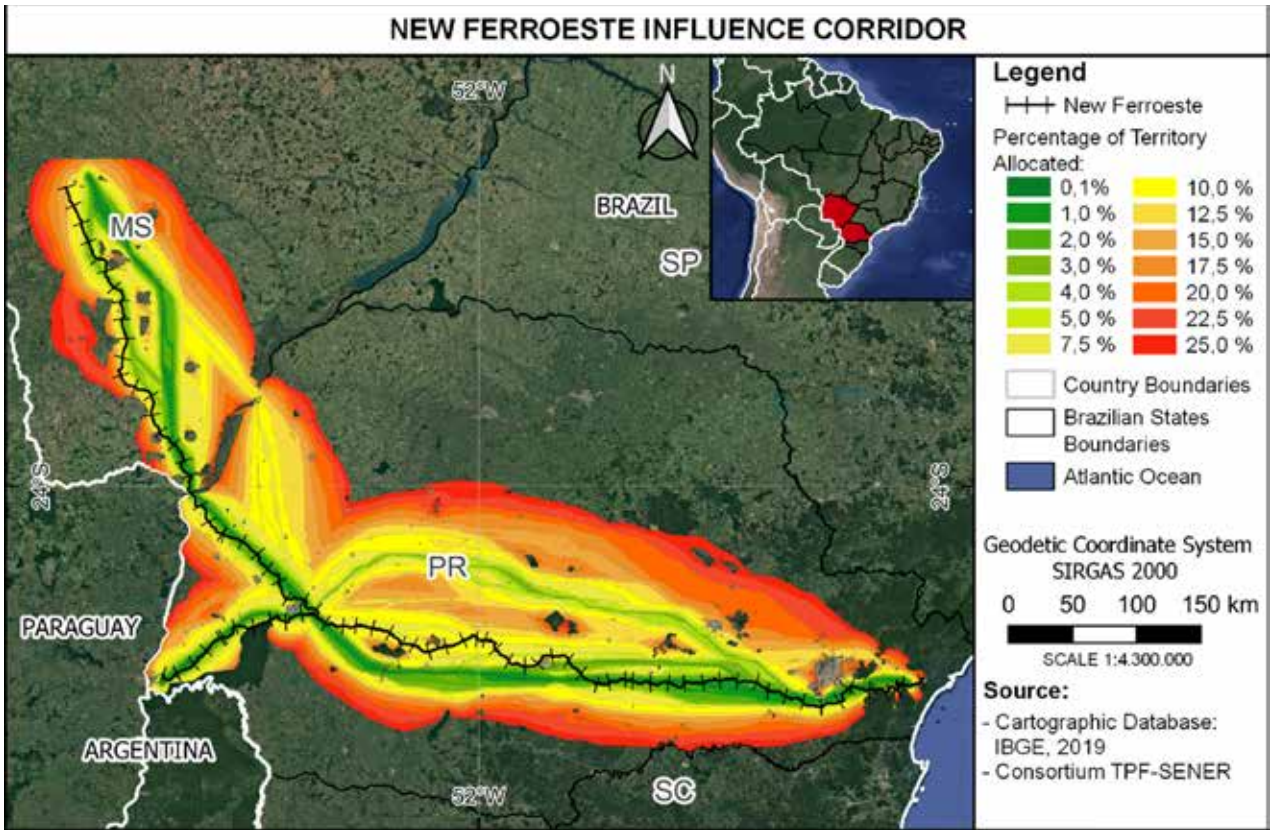

Figure 3 - Favorability Corridors

Finally, with the best corridors defined, the engineers of the team could gather and perform the refinements to determine the trace to be chosen, which is not necessarily the best one indicated by the algorithm, indicated in dark green. As seen in the image above, the chose one is marked in black.

The creation of this innovative approach combining AHP and AI to the definition of the preliminary trace in railway projects avoided the use of trial-and-error methodology or the use of the iterative traditional approach, which gave celerity and assertiveness to the project. Moreover, one of the most important contributions was to help deviate from sensitive environmental areas, indigenous areas and *quilombola* areas, speeding up the process of environmental licensing, which is a huge achievement due to the bureaucratic and restrictive process in Brazil. This was fundamental to obtain the environmental feasibility of the *New Ferroeste* and the support from the concerned stakeholders once the ecological damage was reduced due to the methodology.

One important remark to be done through the entire process regards the role of the engineers. The use of AI did not exclude their participation in the process but put their work on the spotlight. By directing the efforts to the analysis of the scenarios created by the algorithm and reducing the area of analysis, too large in the traditional approach, the team and the specialists could focus on more strategic tasks and use their time to go deeper in the project or even work on other ones. After the analysis of the obtained results, the team did not choose the best alternative according to the algorithm, but the one defined based on other restrictions, such as existing infrastructure, and the experience of the specialists. In addition, it values the professional, because the specialists need to be really good so that the entire process can work smoothly and be effective.

In light of all the exposed above, the power of innovation and combination of new technologies disrupt the traditional process of conceiving traces to railways, shifting the perspective from a vertical approach, where each specialist must do its part and passes to the next, to a horizontal approach, where they can discuss together at the beginning of the project to achieve the best overall result, increasing the speed and the quality of the outcome.

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/Looking ahead – the big picture for the infrastructure sector?

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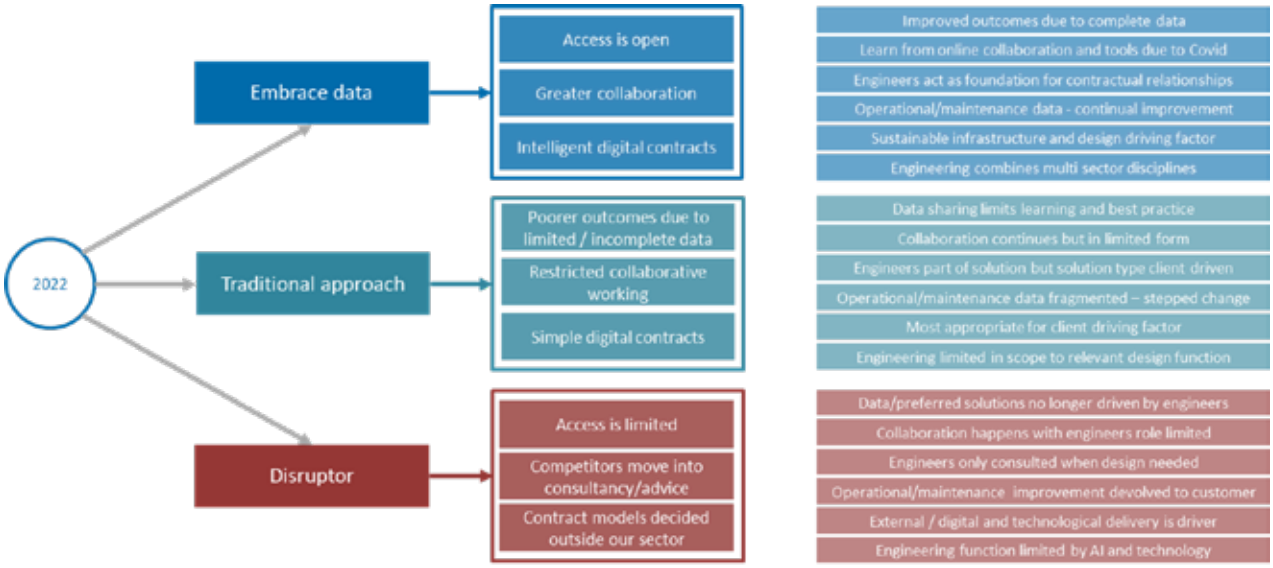
/Looking ahead – the big picture for the infrastructure sector?

This report has discussed the potential for disruption and innovation what could this mean for the sector going forward. As can be seen below at the highest level there are broadly three outcomes that could take place:

1. The sector embraces data and technology within existing firms but also allowing innovation from new entrants where innovative ideas and services improve customer/client outcomes.
2. We continue with the more traditional approach of proprietary data and whilst there are learnings the sector is not taking advantage of the sum of its expertise and data and technology.
3. A disruptor enters due to insufficient innovation and adaption of technology and potentially reduces the role of engineers to the delivery of infrastructure using its data/technology assets.

Sector outcomes from technology changecities work



The above scenarios are not equally balanced in the likelihood of the outcome. The sector has already seen initiatives such as BIM which not only model but share data, collaborative contracts, and more inclusive frameworks etc. Therefore, the traditional approach can already be seen to be under pressure from the need to embrace data and technology and change.

The big question is the scenario of the disruptor and whilst as discussed earlier some signs do suggest the likelihood of such an outcome, there is no clear way to say with certainty whether it will or will not occur.

The infrastructure sector in some respects because of its scale and breadth spanning from roads to water pumping stations, solar panels to railways, covers a wide set of sectors and requirements of customers. This potentially means there will not be one but multiple disruptors making some sectors easier or more difficult/ easy for engineers to influence and operate in.

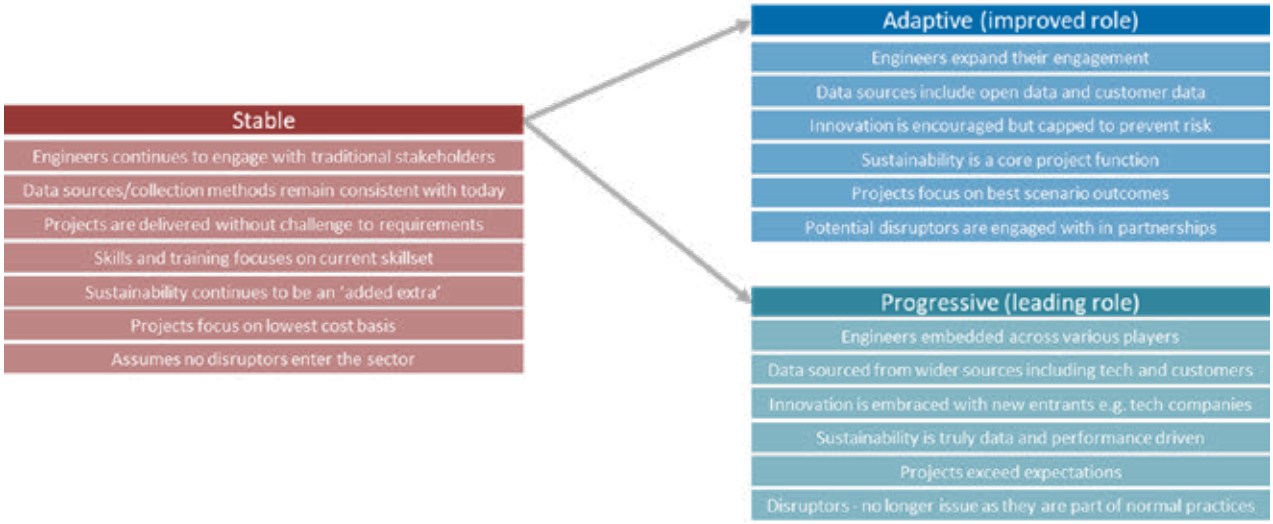
It is therefore important going forward that the sector considers how it wishes to engage in technological change. Broadly speaking there are three potential approaches:

4. The sector engages with technological change in a similar matter to its current situation, where data requirements and technology remain part of a process, but significant shifts are limited.
5. The sector plays a more adaptive approach to technology which is more proactive and will inevitably involve the use of greater data and technology. This could help to drive the sustainability agenda, for example, by embedding it at the core of all projects and not just as an add-on.
6. The final option is that the sector is progressive. In this respect we consider the sector to be an innovator, recognising the significant role of technology and the potential of a disruptor and so going above and beyond to ensure the sector not only plays its role in a data and technology driven infrastructure future, but that we are the core driver and innovator of such change.

/Looking ahead – the big picture for the infrastructure sector?

Considering the events of the past few years with the pandemic, there has already been a significant shift in the use of remote technology and data albeit due to circumstances that should not be unforeseen (pandemics do occur) were realistically hard to predict and were never anticipated to affect the entire globe and all markets simultaneously.

Approaches of the sector for technological change



The pandemic did, however, create a shift change in working patterns and the use of technology for many sectors, including the infrastructure sector. As such, it could be argued that the stable or status quo situation is not realistic and/or should not be what is encouraged across the sector.

Given the above, this presents the sector including engineers with a choice. To what extent does the sector want to be proactive and engage and embrace technology and data? Are we simply doing it to adapt or are we doing it to be progressive? Given the findings of FIDIC's *State of the World* programme in 2021, which suggests we need to spend $7tn a year to meet the SDGs and that net zero targets need to come forward to 2045, this would seem to suggest we need to push towards a more progressive position.

The above also would mean changes and developments in the role of engineers which would be widespread but include:

- Improving real-time data collection and analysis.
- Improve the monitoring of episodes from the different points of view of the agents involved.
- Implementing good prediction models and their consequent impacts as decision-making support tools.
- Better asset management and use of data to target expenditure.
- Including uncertainty in predictions as well as procedures for continuous evaluation of the predictions.
- Incorporating more and better diffused information through crowdsourcing systems. Designing open platforms for the integration of information and forecasts, with different levels of users and information.
- Sustainability built into every model.
- Waste reduction and decommissioning resulting in a high level of resource optimisation on all projects become the norm.
- Circular economy thinking on all projects.

/Looking ahead – the big picture for the infrastructure sector?

- Linking with technology and data providers to push the boundaries of what is possible to achieve, measure, monitor and continually improve.
- Engage directly with customers via technological means and use almost real-time consumer led data to design infrastructure.
- The implementation of AI tools to prevent disruption.
- Pricing models and customer models that favour data collection and technological solutions that aid the efficient running of infrastructure.

The above means that companies will also need to consider how they build the above into their own working practices and where they sit on the spectrum between being adaptive and progressive.

Below we outline three potential versions of what this could mean for a company.

What kind of organisation are you going to be? [xviii]

Full data-structured organisation – organisations in this position will integrate data, machine learning and importantly the outcomes from data transformation into their activities. You are likely to increasingly resemble a data company than a consultancy company as the data provision between sectors, corporate entities etc expands

Aiming to be data-structured organisation – these organisations will have gone through the process of understand what they have and where they need to be. This transition may take time and may involve growing, being acquired, or even acquiring the relevant skills, data management techniques or even data access to ensure they can compete going forward

Extinct structured organisation – these organisations fail to recognise change and the increasing importance of data in day-to-day operations leading to their cost base being too high and ultimately their business model failing.

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/Technology is no longer about process it drives communication

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/Technology is no longer about process it drives communication

Communication and its usage continue to evolve and so too must companies

Communication, it is as simple as sending a letter or an email. In an increasingly connected and digital age, communication channels the opportunities and risks that exist are not only in flux but changing faster than ever.

Many individuals are on the internet nowadays. They access the web through their PCs, laptops, tablets, and mobile devices. Individuals have a Facebook page, Twitter accounts, LinkedIn and some even have a website and so are no longer communicating via one channel. There are over three billion people on the internet today; as an organisation, it's important to remain current on technology or face closing shop. Keeping ahead of technology is a necessity if your organisation wishes to achieve long term stability and growth.

To have access to technology we need to have access to information, to be able to find it as fast as possible, to communicate between each other and exchange information. All types of organisations must introduce digital workplace strategies capable of improving collaboration and communication, and enabling personnel to work together effectively, regardless of location or device.

Such communication and linkages with mapping software and applications have meant that live updates on things such as traffic, train locations, repairs etc. are all linked into individuals own technology devices allowing them to respond proactively.

Another aspect on how communication tools can be used is an example on how social media was used in a flood event for Northern Ireland. Although social media is currently used in combination with traditional measures, during many recent extreme events it has been preeminent, broadcasting vital information before mainstream media. [xix]

The routine usage of social media in everyday life has led to public expectation that emergency services and local authorities will communicate via social media during natural disasters. Extensive research exists which examines how social media has previously been used with regards to flood events. Although the limitations of social media networks cannot be disregarded, they have the potential to play a pivotal role during flood events, such as broadcasting flood warnings and public health advice. This shows how communications, technology and infrastructure can not only improve engagement but also save and rebuild lives.

Sectors are therefore starting to take communication via digital technology much more seriously to manage not only day-to-day events but crisis. For example, the International Water Association has published the book *Water Communication - Analysis of Strategies and Campaigns from the Water Sector* by Celine Herve-Bazin, which aims at setting a first general outlook at what communication on water means, who communicates and on what topics. It is a vital resource for communication managers, utility managers and policy makers involved in water management and students in water sciences and environment.

We are also starting to see closer to real-time information with smart meters across multiple sectors, enabling customers to access their usage information faster and adjust behaviours instantly rather than once a quarter or year as was previously the case.

How did we get here?

Around 16 years ago, Facebook was founded to aid university students share research material and ideas. Today it's a company with a market capitalisation approaching $600bn.[xx] The reason to use this example is not to suggest Facebook represents all communication, but on its journey, it has helped to shape the way communication has changed.

For example, [xxi] Facebook's "Like" button was launched in 2009 which has subsequently been expanded to other emotions. It bought WhatsApp and Instagram as it wanted to enter the direct messaging market and there are over 600,000 attempts to hack its network each day.

But why is how we got here so important for a company? Let's start with external communications as these are more directly linked and influenced by social media. According to a recent report [xxii] by Globalwebindex, globally, digital consumers are now spending an average of two hours and 23 minutes per day on social networks and messaging. Looking at country specific data, this varies from 45 minutes a day in Japan to over four hours in the Philippines.

/Technology is no longer about process it drives communication

The report also discusses, however, that users are being more selective about the time they spend on such platforms as the question of digital wellbeing has moved up the political and social agenda.

This suggests that companies whilst using social media to raise awareness of their brand, products, goods, and services are going to have to be more targeted in their approach, not only to individuals' preferences, but regional, national and local markets as well as optimising the type of media channel they use going forward.

Social media communications and selling

Selling via digital media is also not as straightforward as it is made to believe. Whilst there are users that engage and adverts that can target their interests, individuals more than ever actively employ software to stop such adverts appearing.

What is a click, like, retweet, comment worth to a business? For review sites, such as those for restaurants, validation of product quality and cost by peers can be a powerful motivator to improve sales, but also a powerful deterrent if things start to go wrong and the company is not engaged.

Within this, there is also a trend towards consumption on mobile devices. 25 years ago, individuals had desktop PCs, 15 years ago laptops and better internet speeds started to see people work outside the office. Ten years ago, data started shifting into the cloud to allow hot-desking and remote working and there was the launch of devices such as the iPad. These now bring social media applications and communications to the palm of people's hands on a continual basis.

Positive progress, right? What's the risk?

Positive for business? You can access your customers? Maybe? Such data and communication carry their own risks. The Cambridge Analytica scandal demonstrated to individuals the power of these networks to target and use dig data to achieve an outcome, but also the risk of losing control.

So, there is public and reputation risk but there are other communication issues that have been created out of such networks. Staff are increasingly using networks and channels to communicate with colleagues and stakeholders outside of traditional locked and controlled business solutions. This again introduces a new area of risk.

What about within business and what's next?

Welcome to the advent of a new set of business-focused social networks, such as Yammer, Teams, Facebook for business etc. These offer companies control but they do not totally remove commercial risk. For example, items placed on these networks could be subject to freedom of information requests and as they are treated as more informal than other communication methods there is a risk associated with the more casual nature of their use.

This is, however, not the end of the complexity of the communications journey as there are other interesting developments that have occurred recently but have still not yet filtered through to operate at their potential.

/Technology is no longer about process it drives communication

For example, in June 2016, Microsoft announced that it would acquire LinkedIn for $196 per share in an all-cash transaction valued at $26.2bn, inclusive of LinkedIn's net cash [xxiii]. Why? Was the initial question asked? Looking at a World Bank Group and LinkedIn report on data insights [xxiv] that was written in 2013, yes, a full three years before the purchase by Microsoft, the ability to interpret employment trends, market performance, skill penetration, wages and diversity was significant.

Given their latest user numbers, that network currently gives companies and professionals, of which there are over 575 million of their networks, a place to communicate, negotiate and share knowledge. [xxv]

Now, imagine you connect this to one of the most powerful and developing business tool sets in the market (Office 365) which includes more traditional media channels such as Skype/Outlook and the potential to shift the way business operate internally also starts to change.

What if you could find individuals outside your organisation straight in Outlook? See the details of attendees at the click of a button? Manage your diversity? Filter internal and external staff by skill sets, articles, and training? Let's also not forget about using the platform for recruitment.

LinkedIn has already taken great strides into the recruitment and knowledge sharing areas and staff appear to be happy to use what is seen as a professional network for promoting/managing their careers and contacts. This could therefore raise a whole new set of questions about risk, which is why companies need to be continually aware of communication tolls and channels and their usage.

Given the above, the choice of simply not engaging in channels is no longer really a sufficient risk mitigation strategy. Individuals, staff, companies etc will engage via these channels and if you are not part of the message you will end up being dictated by it.

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Reviewers

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Contributors

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FIDIC, the International Federation of Consulting Engineers, is the global representative body for national associations of consulting engineers and represents over one million engineering professionals and 40,000 firms in more than 100 countries worldwide.

Founded in 1913, FIDIC is charged with promoting and implementing the consulting engineering industry's strategic goals on behalf of its member associations and to disseminate information and resources of interest to its members. Today, FIDIC membership covers over 100 countries of the world.

FIDIC, in the furtherance of its goals, publishes international standard forms of contracts for works and for clients, consultants, sub-consultants, joint ventures and representatives, together with related materials such as standard pre-qualification forms.

FIDIC also publishes business practice documents such as policy statements, position papers, guidelines, training manuals and training resource kits in the areas of management systems (quality management, risk management, business integrity management, environment management, sustainability) and business processes (consultant selection, quality-based selection, tendering, procurement, insurance, liability, technology transfer, capacity building).

FIDIC organises the annual FIDIC International Infrastructure Conference and an extensive Programmeme of seminars, capacity building workshops and training courses.

FIDIC 2020-2024 priorities

Lead the consulting and engineering industry visibly and effectively:

- Being the industry's credible global voice
- Providing the nexus for all stakeholders
- Facilitating improvement and growth in business
- Addressing global challenges

All of the above is for the benefit of society, FIDIC members and their member firms.

/Recent FIDIC policy documents

State of the World Series - Net Zero - What Next?

Net Zero. It could be argued that we have only just begun, but such ambitions were set decades ago. Yes, to hit a target you first have to create one and to reach that target you have to gain acceptance, political support, industry support and then delivery through all related activity. FIDIC, as the global voice of engineering and infrastructure, asks not only what is next but we also provide the next global target. This target not only helps to achieve our current trajectory but also sets the kind of ambitions the engineering sector and humanity should be proud to achieve. We go beyond Net Zero and ask "what next?" Find out more about what comes next after Net Zero by attending the launch of "Net Zero... so, what next?", the fifth report in the FIDIC State of the World series.

Click here to download

State of the World Series - Building sustainable communities in a post-Covid world

The world is gradually learning what it means to be sustainable as we march towards achieving the 2030 UN Sustainable Development Goals and approach net zero, but should we simply be adapting our current way of living or thinking about a new way of life? The Covid pandemic has demonstrated that remote working is not just the digital dream of IT professionals and visionaries, but is and can be real life. Do we need cities? Is urbanisation going to continue? Alternatively, should we be looking at the airline industry and the 'hub and spoke' model as the future for communities where most activity can happen locally in a more sustainable way via serviced offices, with only occasional visits to major hubs? The world is changing and this State of the World report asks: "are we changing quick enough to match the way communities want to live not only tomorrow, but today?"

Click here to download

Tackling the global water crisis - State of the World 2020-2021

Water, it falls from the sky, runs in our rivers, fills our lakes, waters our crops and flows through our infrastructure, yet it is more than a monetary product. Yes, having explored the value of water in our second State of the World report, we explore the flip side of this equation. The environment we live in, the pollution that has historically occurred and minimising such pollution in the future, is becoming more important day by day. The SDGs make this clear, but how can industry stand up and lead the way.

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/Recent FIDIC policy documents

Establishing the value of water - State of the World 2020-2021

Water is vital to so many aspects of life, but investment into the infrastructure, environmental mitigations and resilience aspects of this sector for the wellbeing of humans, the environment, food production, energy etc are not sufficient.

This State of the world report therefore asks a very important question what the value of water is, is it valued incorrectly, how this will change and will this finally drive the investment required to meet the SDGs.

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Time to Tn-vest - State of the World 2020-2021

FIDIC as part of this report makes three recommendations for creating investment certainty, to create an SDG capital envelope and to reinvigorate efforts to truly shift to holistic and sustainable investment. These will help industry to move the industry forward and generate positive momentum.

It is therefore Time to Take The Trillion Task seriously, yes one T for every trillion that is estimated to be needed as a minimum to meet the SDG requirements. It is Time to Tn-vest

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FIDIC Strategic Plan 2020-2024

FIDICs has produced its new Strategic Plan for 2020-2024, it summarises FIDICs activity the results from the various appendices and the goals and approach from FIDIC going forward.

The plan includes a summary of the ten key areas identified and the five goals that FIDIC has set in these areas, including its ambition, targets and current performance.

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Disclaimer

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