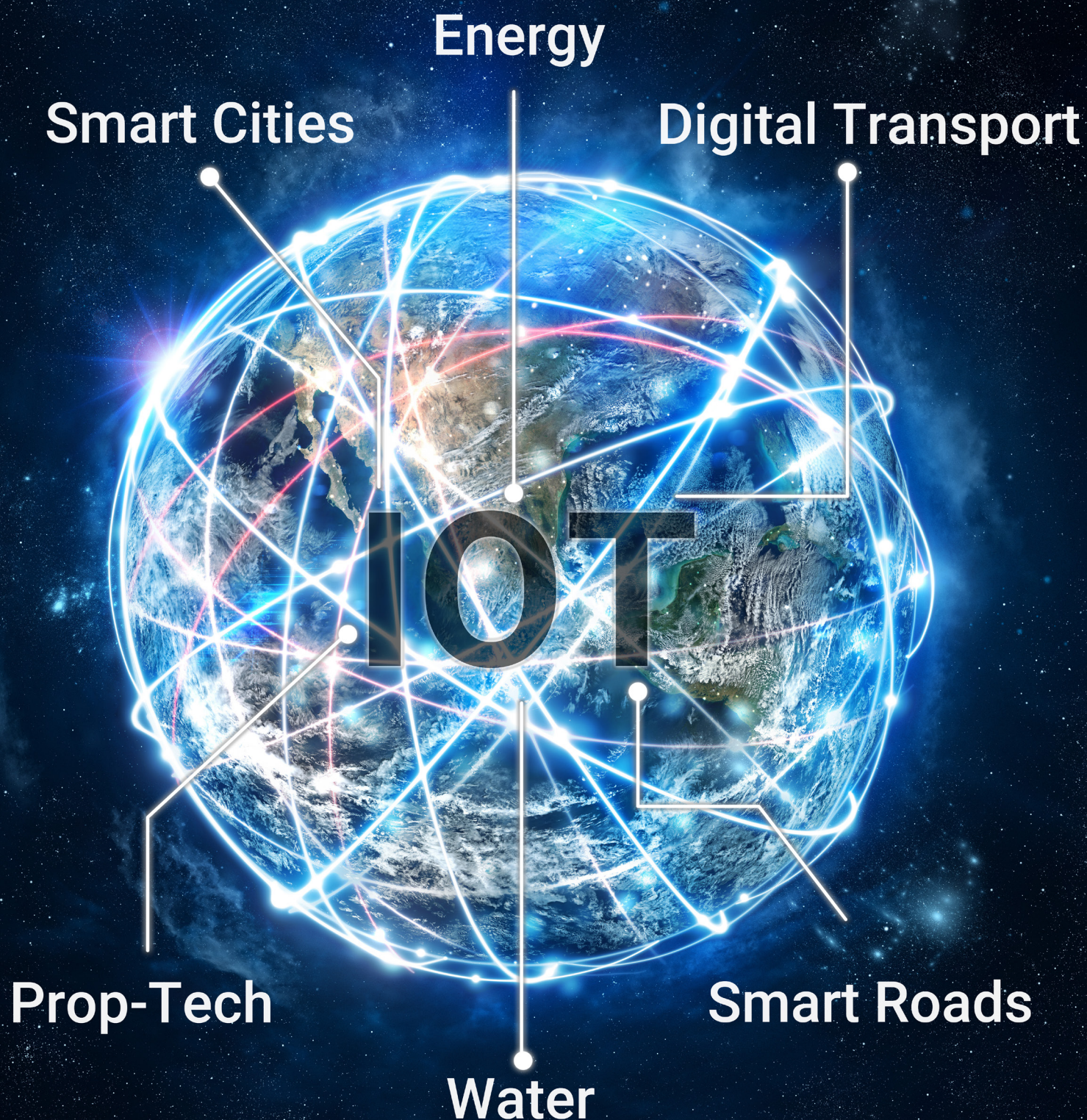


# Digital Infrastructure

## Emergence of New Technologies



REPORT

Capital Raising for Digital Infrastructure



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## Stirling Infrastructure

PARTNERS LTD

Stirling Infrastructure is a leading advisor to institutional investors, listed companies and private market investors for capital allocation. The firm focuses on the sectors in which it has subject matter expertise and a competitive advantage to scale companies across international markets. In relation to digital infrastructure, the firm's central attention is on capital raising and M&A advisory for smart technologies that can impact water, energy, transport and property sectors.

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## FOREWORD

This paper provides an overview of digital infrastructure and evaluates future growth prospects. Supplemented with case studies, this paper offers a comprehensive understanding of the opportunities, risks and prospects posed by digital infrastructure

## EXECUTIVE SUMMARY

Digital infrastructure refers to the application of modern technologies to existing infrastructure. Applying this understanding, Stirling Infrastructure predicts that digital infrastructure will shape our future through the enhancement of infrastructure services. As integration becomes more common, investments will become more efficient, more sustainable and will generate stronger returns.

Digital infrastructure is a broad term, and it covers all of the domains related to infrastructure such as the following, which are included in this paper:<sup>1</sup>

- Water infrastructure such as water treatment and flood management helping to reduce operating and repair costs, saving time, increasing efficiency and safety.
- Energy generation and distribution infrastructures such as decentralised microgrids and wind turbine sensors to help reduce transmission costs, increase reliability for the electricity networks, lengthen the infrastructure's lifetime and increase the system's security.
- Transportation infrastructures such as airports, ports and shipping, railways, and roads help improve the management efficiency of transport hubs, increase safety, allow the ability to track freight, and decrease transport time and maintenance costs.
- Property infrastructure to help save energy, decrease maintenance costs, improve efficiency and make building new property a cheaper process.

In this paper, we provide an introduction to digital infrastructure as well as detailed analysis on various use cases in sectors and countries that are adopting so-called Infratech. Infratech refers to the integration of digital technologies with physical infrastructure to increase efficiency and resilience. The last section of this paper outlines Stirling Infrastructure's expertise in the infrastructure industry and the services we offer to our clients, which include debt and equity financing for infrastructure projects.

<sup>1</sup> Infratech, 2020, <https://www.github.org/blog/what-is-infratech-and-why-is-it-important/>



# INTRODUCTION TO DIGITAL INFRASTRUCTURE

Digital infrastructure is the transformation of public infrastructure to a digitally controlled system. Digital infrastructure includes systems that are vital for sustaining a country. Examples of public infrastructure that can benefit from being digital are water, energy, transport and property. In addition, digitalising public infrastructure offers significant competitive advantages such as cost savings, automation and efficiency. <sup>2</sup>

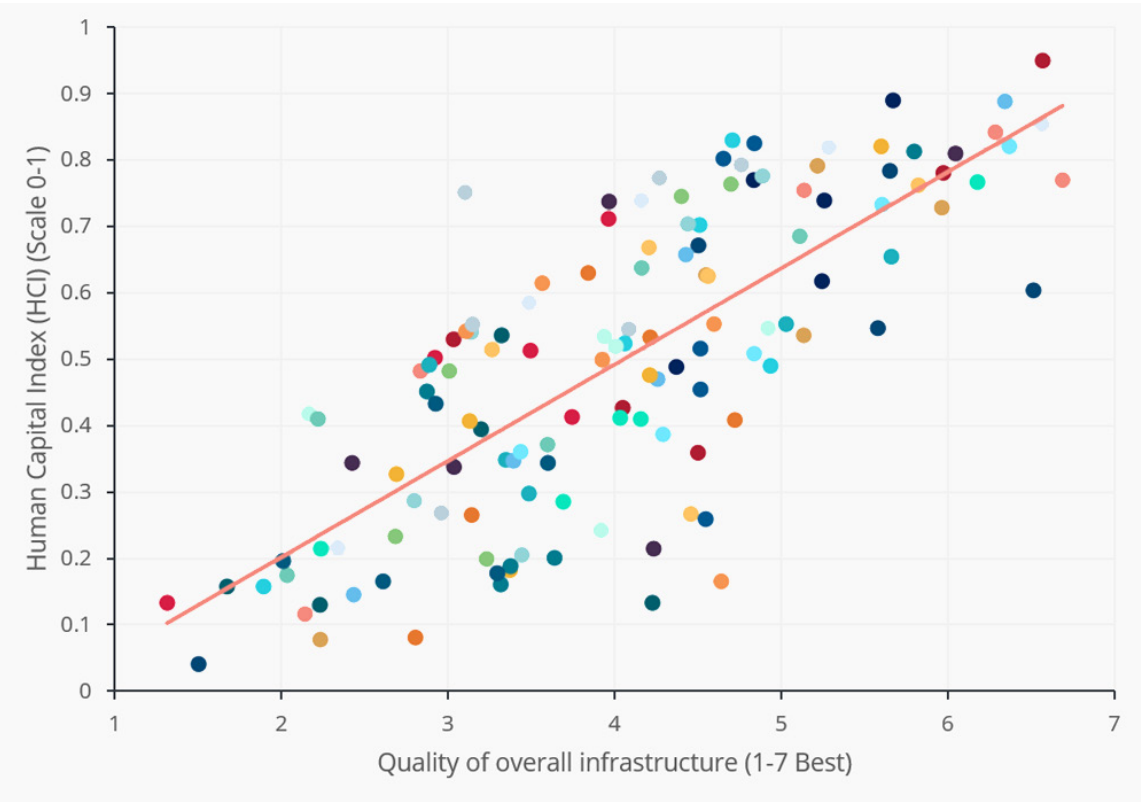
As infrastructure systems become digital, they can be integrated into the same database, allowing for more streamlined data analysis. This technique can be highly beneficial as incorporating data from various sources offers a broader overview of operations. It also provides opportunities to reduce costs, improve productivity and customer satisfaction. In addition, the analysis performed provides a more in-depth understanding of that particular area. An example would be, which roads would have the most significant traffic flow? Or what period of the day has the highest energy consumption in homes?<sup>3 4</sup>

A blockchain-based platform would provide the backbone needed to uphold data transparency and data integrity for digital infrastructure. A blockchain is a decentralised database designed to house significant amounts of information that can be accessed, filtered, and manipulated quickly and easily by many users at once. Please refer to Stirling Infrastructure Partners' paper - *An Introduction to Blockchain* for more information.<sup>5</sup>

## A GLOBAL OUTLOOK ON DIGITAL INFRASTRUCTURE

In 2019, the Global Infrastructure Hub<sup>6</sup> interviewed over 400 industry leaders worldwide. They expressed fear about how geopolitical challenges such as climate change, increasingly frequent natural disasters, and growing social inequality will affect infrastructure globally. The survey also pointed out that Infratech such as the Internet of Things (IoT)/smart infrastructure was perceived to have the highest impact on the industry to address the issues mentioned above.<sup>7</sup>

The chart below outlines the relationship between human capital and quality of overall infrastructure.



Sources:  
Global Infrastructure Hub  
Quality of overall infrastructure (1-7 Best): World Economic Forum Global Competitiveness Index  
Human capital index (HCI) (scale 0-1): World Bank - World Development Indicators

2 Infrastructure technology, 2020, <https://www.gihub.org/infrastructure-technology-use-cases/>  
3 Digital infrastructure,2021, <https://tomorrow.city/a/what-is-digital-infrastructure-and-examples-of-its-application>  
4 Feedough, Infratech, <https://www.feedough.com/what-is-infratech/>  
5 Blockchain benefits, 2018, <https://www.ibm.com/blogs/blockchain/2018/02/top-five-blockchain-benefits-transforming-your-industry/>  
6 GIHub, 2020, <https://www.gihub.org/blog/what-is-infratech-and-why-is-it-important/>  
7 GIHub, use cases, 2020, <https://www.gihub.org/infrastructure-technology-use-cases/>

Human capital is defined as the skills, health, knowledge and resilience attained by people. It is a strong indicator of the extent to which countries can realise full productivity potential of their people. However, we should acknowledge that there are factors other than human capital which contribute to a country's production potential. An example of a country with high human capital index as defined by the World Bank is Singapore at 0.88. Meanwhile, Niger has a human capital of just 0.32.<sup>8</sup>

The previous chart shows that there is a positive correlation between infrastructure quality and human capital development across countries. Infrastructure quality is calculated based on the following factors: road connectivity index, quality of roads, railroad density, the efficiency of train services, airport connectivity, the efficiency of air transport services, liner shipping connectivity index, the efficiency of seaport services, electrification rate, electric power transmission and distribution losses, exposure to unsafe drinking water and reliability of water supply. When workers have better knowledge and skills as indicated by higher human capital, the country gains a competitive advantage because its workforce is more productive.

Countries with higher quality infrastructure such as hospitals are able to provide better healthcare services to their people, increasing overall productivity and therefore human capital.

In the following section, we will dive deeper into the Infratech use cases in different sectors ranging from water to property and also provide case studies on smart infrastructure projects that some countries are undertaking.

8 <https://www.worldbank.org/en/publication/human-capital>







## BUSINESS USE CASES FOR EACH SECTOR DESCRIBED PREVIOUSLY

### WATER

#### Intelligent process optimisation for water treatment

**Technology type: Analytics, AI augmentation, digital twins**

This technology leverages AI driven data analytics to treat water to a better standard and reduce operational costs by up to 10%.

Self-learning AI technologies can analyse historical and current treatment plant sensor data and patterns in real time to control the processes themselves and/or provide real-time decision support for treatment plant operators in the form of performance projections and recommended actions.<sup>9</sup>

However, the use of AI and digital twins in this space is still under development. One major challenge is the creation of a digital twin that can replicate the chemistry of water treatment processes within the treatment plant. Without a digital twin based on sound theory, the AI could potentially provide poor decision support when faced with input data that varied significantly from historical data.

Another challenge is the availability of historical data which in turn relies on sufficient sensors throughout the treatment processes. Without enough historical data, it requires the AI to take more time learn how to best optimise the treatment processes.

One example is Createch360. It is an optimisation software that has been applied at the Brembate wastewater treatment plant in Italy, treating 53,600 m3 of wastewater daily. The software resulted in a 19% reduction in energy consumption with a payback period of 1 to 2 years.<sup>10 11</sup>

#### Automatic prefabrication of stainless-steel pipelines

**Technology type: Construction automation**

Automation saves time and costs on repetitive welds, increasing production efficiency. Robotic welding devices provide increased accuracy, repeatability and throughput for fabricators with high volume applications enabling welders to concentrate on more complicated tasks. Lower costs can also assist to keep local and smaller scale SME fabricators competitive with larger fabrication companies.

One example is K-TIG. It is the developer and manufacturer of a patented, high productivity welding technology. The Acueducto Gran San Juan project in Argentina consists of the installation of a new drinking water system to transport water from wells located approximately 25km west of the city of San Juan to complement the existing water system. 15km of this pipe was fabricated from stainless steel and welded using the automated K-TIG technology.<sup>12</sup>

The project is being jointly funded by the Kuwait Fund for Arabic Economic Development (US\$51 million) and the Argentinean Government (US\$127.6 million). The use of K-TIG transformed the economics of the project and the fabrication was completed in 162 days as opposed to 720 days with traditional welding methods.<sup>13</sup>

#### "Last mile" infrastructure for water provision in developing countries

**Technology type: Sensors**

Last mile infrastructure for the water sector is the connection of water access to a user's home or community.

Developing countries often lack access to clean and safe drinking water, especially in non-urban areas. By combining digital and treatment technologies, this enables last-mile communities to have access to clean water through local water kiosks and community water automatic service providers.

However, the provision of this technology is currently limited to a few providers but future direction can include more provides to offer this in more regions. Moreover, governments could adopt a similar model for water provision where applicable.

Investment platform Untapped and Mathira Water & Sanitation Company (MAWASCO) ran a proof-of-concept project in Malindi, a coastal town in Kenya with a population of over 300,000 installing 6,500 pay as you go smart meters on an 18-month capital lease. Over 3 years, MAWASCO recovered billing arrears and saved operating costs while covering their equipment lease payments. In addition, the cash flow going through the UntappedDigital Payments Platform was at 5.4x that of lease payments.<sup>14</sup>

9 InfraTech Stock Take of Use Cases, 2020, <https://cdn.github.org/umbraco/media/3060/the-global-infrastructure-hubs-reference-note-on-infratech-stocktakejuly-2020-revised.pdf>

10 Createch360, 2021, <https://www.createch360.com/>

11 SpaceX, 2021, <https://www.spacex.com/>

12 K-TIG, water pipeline project, 2017, <https://www.k-tig.com/2017-blog/k-tigs-role-in-the-construction-of-the-acueducto-gran-san-juan-stainless-steel-water-pipeline>

13 K-TIG, 2021, <https://www.k-tig.com/>

14 Untapped-global, 2021, <https://untapped-global.com/>



## Water height and flood management

### Technology types: Sensors, analytics and IoT

Water height and flood management modelling involves the use of sensors to collect data on the water level, resources, quality and water-related hazards, for a specific geographical area. The data collected is then transmitted to a central system and analysed to enable flood prevention and better water resource management.

Sensor technologies allow for the collection of real-time data regarding water height, conditions and quality. This data is then analysed to create flood patterns for the region. Local authorities can utilise the flood patterns to identify the probability of flooding for each area and provide this information to engineers to improve decision-making while selecting suitable locations for future housing and infrastructure.

The data collected can be integrated into 3D models to control the design of future infrastructure and analyse the flooding risks on existing infrastructure. Implementation trials can be performed with prototypes in near realistic conditions to that of the location in question, to test the efficiency of the structures.

The Oxford Flood Network. is a project built in partnership with Nominet UK and Thing Innovations, comprising of 30 wireless water level sensors to detect levels of water around the city to visualise flooding and river conditions. The network gives a high spatial resolution at a low cost, making it suitable for temporary deployment for catchment studies, community projects and site-specific monitoring. It was set up in 2014 following a series of storms that hit the UK causing flooding over the winter of 2013 and 2014.<sup>15</sup>

## Smart meters

### Technology types: IoT/sensors/, big data, data analytics

Smart meters collect and transmit real time water usage data from residential and industrial end users. The usage data assists in reducing water loss, demand forecasting and optimising network operations, as well as increasing community water efficiency.

Smart metering data insights regarding customer consumption and network operations enable the sector to operate water networks more efficiently thus creating a more engaging experience for customers.

The use of smart meters can reduce water consumption which lowers the cost of sourcing bulk water, treating it and transporting it. An example is Singapore where water usage is already low for a developed country, showed smart metering reduced consumption by a further 5%.<sup>16</sup>

## ENERGY

### Use cases in the home

## Decentralised microgrids and peer-to-peer energy transactions

### Technology type: Analytics

Decentralised microgrids use distributed ledger technologies to enable peer to peer transactions of electricity. As a result, the decentralised microgrid reduces distribution and transmission costs for consumers and creates greater reliability for the electricity networks.

In a decentralised microgrid, users participate in peer-to-peer trading that enables users to sell their surplus energy. The peer-to-peer network has two layers: the virtual layer and the physical layer. The virtual layer is a secure link between users; all the information must pass through the decentralised microgrid. It provides equal access to all participants and facilitates orders to buy and sell electricity. The physical layer refers to the network that executes the transfer of electricity from sellers to buyers once the transaction is completed in the virtual layer.

The demand for electricity rises in line with the population and other factors, such as technological advances needing additional electricity. Increasing demand and reliance on renewable energy sources are stretching centralised energy networks. The energy networks are experiencing more power outages and disruptions. Microgrids can help solve this by decentralising control over the microgrid and connecting to or disengaging from the wider grid as required.<sup>17</sup>

When the electricity within the microgrid is insufficient to meet the demand, additional energy from the wider grid can make up for the deficit. Conversely, when the energy in the microgrid exceeds demand, the microgrid can feed the excess energy supply back to the wider grid. If the wider grid experiences a power outage, the microgrid can disconnect and function in isolation, thereby guaranteeing a reliable energy source for users. Peer-to-peer transactions can also help to reduce the demand on the wider energy grid, particularly during peak periods.<sup>18</sup>

## Industrial business use cases

### Technology type: sensors, cameras, IoT

Wind turbines can reach monumental sizes, sometimes over 100 metres in length, even though the sensors mounted on the wind turbines are only centimetres long. They play essential roles in keeping the turbines functioning in the face of extraordinary stresses, vibration, and various other hazards. Without sensors, wind turbines would be less safe, more expensive to run, unable to accurately predict and self-correct impending malfunctions, or shorten their operating lifetime.

There are many different optical and electrical sensors utilised in wind turbines. They detect, monitor, and report information such as changes in the distance between two external bodies near each other. In addition, they monitor levels of vibration that, if excessive, can cause significant damage to the turbine that could lead to costly repairs, and they observe changes in temperature, pressure, and mechanical stresses.

One of the most common types of sensors in wind turbines is "eddy current sensors", also called Foucault currents. They detect variations in the electrical current produced when a conductive material enters a moving magnetic field. When this occurs, changes in distance can alter the strength of the magnetic field. In wind turbines, eddy current sensors regulate the lubricating gap of the shaft to ensure that a thin film of oil will always cover the shaft.<sup>19</sup>

Although the sensors can resist oil, high pressure, and temperature, they reliably monitor the oil gap under hostile conditions. If the gap becomes too large and exceeds its specifications, the sensor can alert maintenance workers to perform preventive maintenance before the shaft binds or seizes.

## Energy storage and distribution

### Technology type: Analytics, IoT

Digital technologies make energy storage and distribution systems more connected, capable, efficient, reliable and sustainable. Many everyday energy infrastructures such as solar panels, meters, energy storage systems, thermostats, appliances, and building controls adapt to combine with digital software for optimisation.

This software builds data analytics or planning information that allows for a new form of aggregation which gives a greater engagement in managing energy consumption and selling surplus electricity through managing individual energy systems.<sup>20</sup>

Digital infrastructure can reduce downtime and extend the operational lifetime of energy storage and distribution assets through monitoring and deploying solutions that rely on their digital component. This digitisation allows more digital applications to optimise and stay competitive with the alternatives in renewables.<sup>21</sup>

## Oil ownership disputes between companies in storage

### Technology type: Analytics

A blockchain can act as a decentralised public database that collects information about the proportion of oil in a mass storage tank that an oil company owns. As a result, the decentralised public database reduces uncertainty about the ownership of oil as the system is transparent. Therefore, any transactions are available for all parties to see, reducing fraud opportunities.

<sup>15</sup> Saving water, 2021, <https://www.suezsmartsolutions.com/en/blog/what-if-saving-water-became-a-game>

<sup>16</sup> Singapore smart water meter, 2021, <https://www.pub.gov.sg/smartwatermeterprogramme>

<sup>17</sup> Digitization of energy, 2021, <https://paul4innovating.com/the-digitization-of-energy/>

<sup>18</sup> Energy efficiency, 2020, [https://unece.org/sites/default/files/2020-12/GEEE-7.2020.INF\\_3.pdf](https://unece.org/sites/default/files/2020-12/GEEE-7.2020.INF_3.pdf)

<sup>19</sup> Wind turbine sensors, 2021, <https://eu.mouser.com/applications/tiny-Sensors-Role-in-Wind-Turbines/>

<sup>20</sup> Digitization of energy, 2021, <https://paul4innovating.com/the-digitization-of-energy/>

<sup>21</sup> Energy efficiency, 2020, [https://unece.org/sites/default/files/2020-12/GEEE-7.2020.INF\\_3.pdf](https://unece.org/sites/default/files/2020-12/GEEE-7.2020.INF_3.pdf)





When managing oil worth many millions of dollars, blockchain databases have many benefits over traditional systems:

**More transparency:** Transaction histories are becoming more transparent through the use of blockchain technology. Blockchain is a type of distributed ledger, so all network participants share the same database. That shared database can only update through a consensus. For a transaction record to change, the entire network must collude. For this to happen, all the subsequent records must also change.

**Enhanced security:** Recorded transactions must be agreed upon by a consensus. After a transaction is approved, it is encrypted and joined to the prior transaction. Information is also stored across a network of computers instead of on a single server, making it difficult for hackers to alter data.

**Improved traceability:** When valuable oil navigates through a complex supply chain, it can be hard to trace an item back to its origin or owner. When the oil's owner gets recorded on a blockchain, it leaves an audit trail that shows where an asset came from and every stop it made on its journey. This historical transaction data can help to verify the authenticity of assets and prevent fraud.

**Increased efficiency and speed:** A centralised database is time-consuming to maintain and prone to human error. It often requires third-party mediation. By streamlining and automating these processes with blockchain, the companies that own the oil can complete transactions faster and more efficiently. Since record-keeping occurs using a single digital ledger shared among co-operators, there is no need to adjust multiple databases therefore saving time. When everyone has access to the same information, it becomes easier to trust each other without numerous intermediaries, so clearing and settlement can happen much quicker.

**Reduced costs:** With blockchain databases, third parties become irrelevant as each party can trust the other. This trust stems from the data on the blockchain being trustworthy. In addition, less documentation is needed to complete a transaction because everyone will have access to a single, immutable version of all the transactions.

## TRANSPORT

### Airports

#### Unmanned aerial vehicles (UAVs) for passenger travel

##### Technology types: Sensors, cameras, IoT

UAVs are drone like aircrafts without an onboard pilot. They operate with varying degrees of autonomy, such as remote control by a human operator or autonomously by onboard computers. They operate using a combination of technologies including computer vision from CCTV, AI and object avoidance technology.

There are multiple potential applications for UAVs as new models of mobility. UAVs can operate as point-to-point passenger transport (air taxi), operating in a similar way as today's car-based ride hailing services. They could act as short-range shuttle services to/from airports in urban centres and/or medium-to long-range intercity fixed flight operations. In the freight sector, UAVs could act as a point to-point freight last mile solution or consumer delivery service. This can minimise road congestion, delivery costs, fuel emissions and reducing the demand for street parking in the urban centres.

One example is Volocopter which obtained permits to fly in Germany. However, it involves high implementation costs for the UAV development, and for the required supporting infrastructure. Safety is a challenge to achieve and requires additional safety requirements to be checked.<sup>22</sup>

#### Digital service platforms for transportation hubs

##### Technology types: Communications, analytics

Digital service platform combines the latest digital and communication technologies such as cloud computing, 5G, big data and IoT and can improve the operation and management efficiency of transport hubs. It harnesses economic, social and corporate governance (ESG) benefits, and enhances the security and quality of services.

In addition, it improves efficiency and reduces costs because micro-service architecture built on cloud platforms can realise virtual dynamic allocation of underlying computing resources and high-availability modes of operation, which reduces the construction and operation cost of fixed servers.

The world's biggest airport, Beijing Daxing International Airport, recently adopted such technology . One ID model can recognise and verify users' identities through data matching process. According to statistics from the Beijing Daxing International Airport, this technology helps expedite screening at the security gates significantly, with each processing device handling 260 people per hour.<sup>23</sup>

<sup>22</sup> Volocopter, 2018, <https://www.volocopter.com/newsroom/infrastructure-to-integrate-and-scale-air-taxi-services-in-cities/>

<sup>23</sup> Virtual reality building inspection, 2017, <https://www.iothub.com.au/news/could-virtual-reality-streamline-building-inspections-449339>



## Ports and Shipping

### Automated robot cranes (ARC) for ports

**Technology types:** Sensors, cameras, IoT

ARC are cranes that are integrated with AI. The ARC can perform tasks autonomously or be controlled remotely by humans. They have object detection capabilities which helps to identify workers or objects nearby in order to avoid collisions, accidents and delays during operations. They can be installed at shipping ports and container terminals to replace traditional driver operated cranes.

By merging AI technology to crane machinery, ARC can optimise the performance of these tasks whilst reducing the risk of mistakes, accidents, injury and delay. Through this optimisation, cost savings can be made for the operator associated with the decrease in time required to perform tasks, reduction in damage to equipment and cargo, reduction in workforce injuries and enhanced asset capacity, which can enable cost savings at every level of the supply chain.

One example is the automated container terminal in Shanghai. The terminal is operated by 26 bridge cranes, 130 autonomous vehicles and 120 rail mounted gantry cranes which are remotely controlled. The development cost is USD 2.15 billion. The operator hopes to save up to USD 80,000 in terminal operation costs per vessel via a 70% reduction in labour costs and a 50% increase in handling efficiency. Carbon emissions are also expected to decrease by 10%.<sup>24</sup>

### AI digital maritime logistics platform

**Technology types:** sensors, communications, analytics and IoT

Digital platforms are developed to facilitate trade and help shippers to better manage the physical movement of goods, trade financing and compliance. By using digital technologies, these platforms aim to reduce inefficiencies for the global supply chain by interacting with systems and applications of various stakeholders.

These digital platforms can also be powered by AI, hence adding several services in terms of supply chain orchestration including providing users with insights on route options, free trade agreements, import/export formalities and other value-added services.

Singapore port operator PSA has partnered with Global eTrade Services (“GeTS”) Asia Pte Ltd, a fully-owned subsidiary of logistics software developer CrimsonLogic, in the development of a global common trade and supply chain platform called CALISTA – an acronym for Cargo, Logistics, Inventory Streamlining & Trade Aggregation – to facilitate trade and help shippers to better manage the physical movement of goods, trade financing and compliance. The system is operational in PSA’s flagship terminals of Singapore and Antwerp.<sup>25</sup>

### Smart containers

**Technology types:** sensors, IoT

Smart containers are shipping containers used in freight and logistics that are integrated with IoT technologies, sensors, GPS tracking and solar panels. The containers are designed to regulate the internal conditions such as temperature to provide real time GPS tracking, enhance security, and provide condition information that can alert operators to any potential issues with the cargo. The information gathered is automatically fed into digital shipment records, which can be shared with the customer to provide the latest, most accurate tracking and can be used to better predict arrival times at ports to enable optimised unloading of containers and distribution to later phases of the supply chain. Smart shipping containers can be self-powered by solar panels on their exterior and have batteries to enable energy to be stored.

The use of smart containers reduces the time required to gather data on the location and condition of containers by implementing an autonomous system that provides automatic updates.

One example is the Silk Road. CIMC develops and deploys technologies integrated into the company's container. It allows connectivity for individual containers more easily and at lower cost.<sup>26</sup>

<sup>24</sup> Shanghai port terminal, 2018, <https://www.dailymail.co.uk/news/article-5604199/The-worlds-biggest-automated-port-terminal-opens-Shanghai.html>

<sup>25</sup> Calista, 2021, <https://calista.globaletrade.services/CALISTAWEB/cusLogin/login.cl>

<sup>26</sup> <https://calista.globaletrade.services/CALISTAWEB/cusLogin/login.cl>

## Vehicle to vehicle (V2V) connectivity

**Technology types:** sensors, communications, IoT

V2V technologies are C-ITS designed to enable communication between vehicles to avoid accidents and warn drivers of impending crashes, as well as to enable the optimisation of the overall traffic flow. The aim of such development is to facilitate the implementation of Autonomous Vehicles in the future, which will heavily rely on their efficiency.

The technology can also improve traffic flow management, decrease congestion, and optimise utilisation of existing infrastructure, thereby minimising any unnecessary expansion of infrastructure capacity. V2V provides data on traffic flows, which is processed and used to share traffic information on variable message signs and variable speed limit signs, and to enable vehicle platooning if all vehicles are connected.

One example is the Queensland CAVI Program. They have trials of several V2V technologies from different manufacturers. However, the initiative involves high costs and a lot of research contribution.<sup>27</sup>

## Rail Assets<sup>28</sup>

### Hyperloop development

**Technology type:** transport mode, IoT

Hyperloop is a proposed mode of ground transport for passenger and freight transportation which consists of pods transported at high speed, through the length of low-pressure tubes that are elevated off the ground, due to a lack of air resistance or friction. Hyperloop has the potential to travel at speeds higher than 1,125km/h which would reduce travel times over medium-range distances up to 1,500 kilometres.

Hyperloop is anticipated to be a fast and carbon-neutral means of connecting cities. Hyperloop systems are envisioned to run exclusively on renewable energies that would enable the system to generate more energy than it will consume. It has been proposed to install solar panels along the outside of the Hyperloop tube, which charge batteries storing energy for use at night.

One example is Hyperloop Alpha. It was described in an August 2013 paper by Elon Musk and proposed a route running from the Los Angeles region to the San Francisco Bay Area. However only the implementation costs were assessed, not the operational costs. It is currently in a pre-feasibility stage.

### 3D printing maintenance work

**Technology type:** IoT

3D printing can be used in many sectors. It enables the creation of entire pieces of infrastructure, such as the MX3D Bridge in Amsterdam, or printers in factories can enable pieces of infrastructure to be prefabricated off site and transported to the construction site for modular construction. However, the relative immaturity of the technology today means that 3D printing in the short term is more frequently used to assist in manufacturing specialist components than completely replace traditional construction techniques.

The main focus of this use case is on using 3D printers to produce individual components on-site to allow for a quick response to maintenance requirements. For example, on-site printers in railway maintenance facilities can enable the rapid production of parts (e.g., chair arm rests or headrests for trains) to replace faulty parts and allow a train to re-enter service. This on-demand 3D printing style is increasingly being adopted in public transport maintenance facilities, such as those operated by Bombardier, Siemens Mobility and Deutsche Bahn.

## Augmented and virtual reality for planning and design

**Technology type:** IoT and analytics

VR replaces the real-world environment with a simulated environment, where computer simulations influence the user's senses and perception through the production of images, sound, and other sensations. The user can look and move around the artificial environment and interact with its virtual features. Similarly, AR is a blend of the real world and the digital world, which is achieved by overlaying virtual computer-generated objects onto real-world objects. Where AR alters the user's ongoing perception of a real-world environment, VR completely replaces the user's real-world environment with a simulated one.

<sup>27</sup> Automated vehicle initiative, 2019, <https://www.tmr.qld.gov.au/About-us/News-and-media/News-and-media-frequently-asked-questions/Cooperative-and-Automated-Vehicle-Initiative-CAVI>

<sup>28</sup> Infratech, 2020, <https://www.github.org/blog/what-is-infratech-and-why-is-it-important/>





Several devices are used in the field of MR including head mounted displays (HMD), AR tablets, Cave Automatic Virtual Environments (CAVE), and AR projectors. These devices provide MR visualisation and other functionalities for user interaction.

The University of Cambridge Trial involves the use of headsets to perform inspections on a bridge. High-resolution photos are mapped to 3D models and using a HoloLens connected to the cloud, the user can zoom in and out, rotate, and move around the structure from anywhere in the world. The solution enables more accurate diagnoses of structural issues, which resulted in fewer large-scale repairs, less downtime, and reduced traffic delays and congestion.

## Roads

### Sensors and robotics for bridge maintenance

**Technology type: sensors, analytics, IoT, construction automation**

In the design, construction and maintenance of a motorway bridge, new technologies can contribute to reduce costs, shorten the construction time, increase quality, efficiency, safety and sustainability with a concrete positive impact over the territory.

The new Genoa bridge over Polcevera river represents a key example of smart and sustainable infrastructure as well as a showcase of Italy's latent engineering and construction talents.<sup>29</sup>

### Electronic tolling

**Technology type: cameras, analytics, IoT**

The solution replaces the toll-collection system based on tolling plazas and physical barriers, for which operational efficiency and long waiting times for vehicles are common problems.

It is expected to result in savings in travel time as well as vehicle operating costs by reducing delays and enabling smoother traffic flows.

The project is expected to have an overall positive environmental and climate impact due to a significant local pollution improvement & fuel consumption/CO2 emission reduction.

One example is DarsGo. It is a modern electronic tolling system in the free traffic flow for vehicles whose maximum permissible weight exceeds 3.5 tonnes. Tolling is made possible with the help of a special DarsGo unit, which must be installed inside the vehicle.<sup>30</sup>

### Dynamic Road Pricing

**Technology type: cameras, analytics, IoT**

It is the practice of varying the price of a toll that reflects the changing demand on that infrastructure. The price to use the relevant infrastructure would be higher during peak hours. However, the price can be fully dynamic and fluctuate in real time with demand.

There are 4 common road pricing models: location specific, corridor specific, partial network schemes and whole of network schemes.

One of the examples is Stockholm dynamic congestion zone and bridge tolls. The cordon scheme uses automatic number plate recognition in a 35km<sup>2</sup> zone. The scheme was launched in 2007 after a successful trial in 2006. In 2016 the scheme was updated to a dynamic pricing system based on time of day.

### Satellite Based Navigation to Optimise Traffic Flows

**Technology type: communications, analytics**

Regional navigation and information system (RNIS) serves as a single access point to the monitoring and reference information about public transport operating in the region.

It allows government agencies, local governments and their subordinate organisations to conduct online centralised remote monitoring of the current location and condition of certain vehicles, control their movement as well as quickly respond to cases of unforeseen circumstances or violations of the route schedule.

<sup>29</sup> New Genoa Bridge, 2020, <https://www.forbes.com/sites/iredominioni/2020/06/23/italy-completes-new-genoa-bridge-after-2018-deadly-disaster/?sh=696e8560164e>

<sup>30</sup> Darsgo, 2021, <https://www.darsgo.si/portal/en/about-us>



## Smart Street Lighting

**Technology type: sensors, cameras, IoT**

Smart street lighting can be integrated into a wider management platform for collecting and processing smart city sensors' data related to transport, energy and city management safety and security.

Smart street lighting and sensors can be combined with communication technology, digital signage, CCTV, speakers and electric vehicle charging.

One example is Shanghai smart lighting. The city is equipped with streetlamps with touch screen, surveillance cameras, free WIFI, area traffic condition information, etc. However there involves high costs to implement the backbone assets infrastructure; safety and traffic management benefits are to be assessed.<sup>31</sup>

## Smart parking infrastructure

**Technology type: sensors, cameras, analytics, IoT**

It is a parking solution that can include in-ground smart parking detection/counting sensors or cameras. These devices are usually embedded into parking spots or positioned next to them to detect whether parking bays are free or occupied and this happens through real time data collection.

Then the data is transmitted to a smart parking mobile application which communicates the availability to its users.

SFPark, San Francisco's smart parking pilot combines real time data indicating where parking is available and dynamic parking pricing to make parking easier for drivers as well as improving utilisation of parking infrastructure. It has since been implemented permanently.<sup>32</sup>

## Real-time traffic management

**Technology type: sensors, cameras, communications**

It manages traffic behaviours in real time by utilising a network of technologies including sensors, smart cameras, GPS and Bluetooth/WiFi which can be used to efficiently reduce congestion and other traffic issues.

Real-time data can be utilised to suggest alternate routes to drivers when routes are congested and indicate to public transport operators and decision makers where user demand and supply is located.

One example is the active traffic management approach in the UK. This is a development of a fully remotely controlled motorway with variable message signs in order to manage traffic flow and land use.<sup>33</sup>

## Electric Vehicle Charging Cloud Platform

**Technology type: sensors, communications, analytics, IoT**

The system consists of varying technologies of chargers (slow, fast and ultra-fast) and EV Cloud Platform.

This solution aims at providing several functionalities including monitoring and analysing charger's usage, setting prices, accessing to chargers and resolving incidents remotely, therefore lowering operational costs substantially and improving operational efficiency.

One example is the Allego EV-Cloud.<sup>34</sup>

## PROPERTY

### Digitally controlling household appliances (Smart homes)

**Technology types: sensors/IoT, big data, data analytics.**

Digitally controlling household appliances involves using sensors on standard devices such as washing machines, refrigerators, speakers, televisions, security systems, baby monitoring and cleaners. Data from the appliance improves the performance and ensures the appliance is working as intended for the task at hand. In addition, devices in a home are connected through an internet connection, allowing someone to control the functions remotely.

People can keep all the appliances in their homes connected and functioning efficiently through an interface connected to the internet. They can control many aspects of their home, like the temperature and how often cleaning happens automatically or from their phone. It is possible to make the home more energy-efficient for example, the person could control when the heating turns on.

AI technology can digitally control household appliances. It can efficiently track all the activities through a connected system. Furthermore, it also offers around the clock troubleshooting, and diagnostics can be provided by monitoring any appliance's energy usage and usage patterns.

Digitally controlling household appliances allows electricity consumption to be tracked and sent in real-time to a database. The database monitors the use times and electricity consumption of the appliances to help save energy.<sup>35</sup>

One example is a user remotely controlling a smart washing machine. It alerts the user about the washing cycle progress, errors or threats, and the energy rate. In addition, a user can monitor the cycle in the washing and drying process and get notified when the drying process has finished. Homeowners can save money by operating appliances during off-peak times, eliminating the need for the power plant to generate more electricity.<sup>36 37</sup>

### Volume of people building houses

**Technology types: communications, analytics**

Technology can make it cheaper to generate new housing units as 3D printing and modular housing construction have reduced homebuilding prices.

This technology reduces the cost and time of construction by working within a controlled environment. In addition, it allows for productivity regardless of the weather and decreases the amount of physical labour used for a traditional, stick-built home.

Technology also helps the contractors and project managers who build houses to monitor their work progress remotely without having to travel to the construction site, thus saving time. In addition, employees can use their smartphones to contact each other and update on the progress and send digital pictures for verification and inspection.

One example of digital technology aiding the building of houses is digital software that can help schedule, manage and report work done back to the main office, improving productivity significantly. Most of this software is cloud-based, enabling everyone to access real-time data. This solution can save hundreds of hours every year.<sup>38</sup>

31 Tracking traffic, 2014, <https://www.weforum.org/agenda/2014/07/seven-ways-cities-around-world-tackling-traffic/>

32 Parking pricing, 2017, <https://www.sfmta.com/demand-responsive-parking-pricing>

33 Tracking traffic, 2014, <https://www.weforum.org/agenda/2014/07/seven-ways-cities-around-world-tackling-traffic/>

34 EV Cloud, 2021, <https://www.allego.eu/business/ev-cloud>

35 Smart home, 2021, <https://www.investopedia.com/terms/s/smart-home.asp>

36 Everyday AI, 2021, <https://www.einfochips.com/blog/digitizing-homes-making-everyday-appliances-smarter-with-iot-and-ai/>

37 Smart home automation, 2016, <https://bluespeedav.com/blog/item/7-greatest-advantages-of-smart-home-automation>

38 Technology addressing house affordability, 2019, <https://www.urban.org/urban-wire/four-ways-technology-addressing-housing-affordability-crisis>



## WHY STIRLING INFRASTRUCTURE PARTNERS

### Stirling Infrastructure:

#### Allocates capital responsibly

Stirling Infrastructure is a specialist infrastructure financing and advisory firm focused on identifying sustainable projects that offer safe and profitable returns. Stirling Infrastructure appraises proposals across various infrastructure sectors, supporting clients in structuring transactions by sourcing debt and equity on flexible, competitive terms.

#### Provides refinancing for improved returns

Stirling Infrastructure offers favourable terms for lending and capital restructuring, increasing flexibility and profits, allowing the operating company to plan for future growth and provide value to investors. In addition, Stirling Infrastructure advises on refinancing transactions and has access to a wide range of international and local debt providers.

#### Provides expert management selection

The market provides institutional investors with a vast array of different infrastructure funds. Stirling Infrastructure advises clients on choosing between the many funds and investment strategies within the infrastructure asset class. In addition, Stirling Infrastructure has experience conducting due diligence on fund managers and their strategy using in-house metrics to measure the performance of funds and provide objective analysis to institutional investors.

### STIRLING INFRASTRUCTURE'S INVESTMENT CRITERIA

Stirling Infrastructure specialises in eight areas: battery storage and smart grids, communication infrastructure, electrical power networks, gas, renewable energy, smart infrastructure, transportation, and water and environment. The core business advises asset managers, listed companies, and project sponsors on capital-raising and M&A services in emerging and developed markets.

Size of transaction:

- Minimum 5 million US dollars
- Typically, between 10-250 million US dollars
- Maximum 500 million US dollars

Assessment criteria for the management team:

- Management team with a strong track record or exceptional talent
- Strong commercial awareness
- Excellent academic backgrounds are preferred

Stirling Infrastructure works on transactions that will be of interest to institutional investors and listed companies. Stirling Infrastructure focuses on the following industries:

- Smart cities
- Energy tech
- Transport tech
- Watertech
- Proptech

Stirling Infrastructure will only take on mandates when the firm's team can either bring private markets capital, including institutional investors or strategic capital, to accelerate sustainable growth and income horizontally or vertically into domestic and international markets.

### Equity Financing

Stirling Infrastructure raises equity for infrastructure projects. The equity funds capital raises on direct investments and co-investments. The firm's analysts spend time researching and understanding the investment proposals and appraising the equity capital raise opportunities before deciding if the proposal meets the requirements for an equity raise.

### Debt Financing

Stirling Infrastructure facilitates both debt raises and refinancing arrangements for infrastructure assets. Debt raises may relate to project finance or to operating assets. Stirling Infrastructure can finance projects with debt from local, national, and international banks and private debt funds as a specialist infrastructure financier. The firm uses its relationships from prior transactions to bring cooperative lenders together so that the provision of structured debt is delivered quickly and at competitive rates.

What makes Stirling Infrastructure unique is its market knowledge and relationships with mainstream and specialist infrastructure lenders, some of which are lesser known in the market. The firm does not have a specified restriction on any jurisdiction. Stirling Infrastructure has expertise in:

- Finding the lowest cost of capital, with favourable lending terms, from a variety of lenders for refinancing or non-complex transactions
- Giving more complex capital structures access to specialist lenders, who specialise in unique infrastructure financing and special situations allowing Stirling Infrastructure to offer more bespoke solutions

For Stirling Infrastructure to mitigate risks and optimise returns, all investments presented to the firm get compared against a range of infrastructure KPI metrics. Then, on an objective basis, our sector analysts determine how and whether the investment will perform against comparable transactions and funds. Once the analysts have formed an opinion on the investment proposal, this analysis gets presented to the firm's Investment Board.

The Investment Board consists of infrastructure executives who have substantive experience reviewing similar investments. After the Investment Board meets to discuss the proposal, they will either:

1. Accept the mandate to act as the project sponsor's corporate finance advisor or an advisor to the asset manager for an equity raise
2. Require the project sponsor or asset manager to take further action for an equity raise to be suitable for institutional investors or strategic investors
3. Decline the firm's mandate for an equity raise as the investment opportunity did not meet this firm's benchmarks to pass for a capital raise to institutional investors

The Investment Board accepts mandates that will meet the investment criteria of institutional investors. The Investment Board is satisfied that if a mandate is accepted, Stirling Infrastructure, the firm, is confident that it will achieve a successful capital raise.



## FOR FURTHER INFORMATION

This paper provides insights into the digital and smart infrastructure that Stirling Infrastructure provides M&A and capital raising services for.

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