



# ENTERING THE AGE OF THE 'DIGICENE'

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# Introduction



Patrick Sheehan

“At the risk of sounding fanciful, objects will be able to tell us how they feel.”

Depending on which business or tech circles you mix within, the ‘Internet of Things’ (IoT) may be a term you now hear often, or hardly ever. This disconnect is telling – those that have an inkling of its world-changing potential want to talk of little else. But until there is a clearer idea of how it will change the world, it will not fire up the collective imagination. Part of the difficulty in visualizing its potential is that it links the tiny and ubiquitous with the massive – indeed it has been called the ‘World-Sized Web’<sup>1</sup>. While the first iteration of the internet connected people, the IoT will, in theory, connect every man-made *thing* across the planet.

Comparing this internet of *things* with the internet of *people* that we know so well is a useful way to try to visualise its potential scale. There are many more *things* or *objects* than there are *people*. So in terms of the number of connections at least, the IoT will be much bigger. I was recently on a panel session with Young Sohn of Samsung Electronics who estimates 100 times more connections in ten years time.

It will also be different, not just because of its scale. My fridge will not need to download movies to keep it entertained. Objects are not likely to do Google searches, chat or engage in unproductive activity. On the contrary, they will produce information – and this is where things get interesting. At the risk of sounding fanciful, objects will be able to tell us how they feel. And since objects tend to be quite straightforward, this won’t be a complex and ambiguous stream of consciousness, but in the main rather short and simple actionable information, such as “I have a 60% chance of breaking down in the next 30 days”. As a result, the optimal architecture of this internet will be different, and its impact will be very different.

From our particular perspective – that of investing to achieve sustainability through innovation – we view IoT as a gamechanger.

The development of increasingly smart sensors, low-power technologies and long-life batteries and energy harvesters, coupled with an abundance of computer power, networks and storage, suggests an imminent revolution in the way we can manage the man made world.

1. Bruce Schneier, The internet of things will be the world's biggest robot, [www.schneier.com](http://www.schneier.com)

“Imagine being able to measure locally, continuously and in detail, temperature, pollution, plant growth & sea life, around the world and to take action as a result of such data.”

The Environmental Technologies Fund has already invested in a number of innovative companies that are making the IoT's potential a reality. Take Perpetuum, which allows the wheels, bearings and gearboxes etc., of trains to talk to engineers in real-time about the health of their components and indeed of the track they run on. Or our most recent investment, Telensa, which is making smart street lighting and smart parking a reality, from Moscow to Shanghai. Or take MWR InfoSecurity, a cybersecurity firm helping ensure that smart networks can be deployed safely.

Sometimes the sustainability impact of such companies isn't obvious at first - less so perhaps than the impact of investing in windfarms or electric vehicles - even though their impact may be profound. However, when you think about sustainability through innovation, as we do, it can be easier to connect these dots early. As investors, this is part of the attraction.

IoT also offers the prospect of monitoring much of the natural world, with profound implications for our ability to comprehend and manage scarce resources and our impact upon the environment. Imagine being able to measure in detail, locally and around the world, such important information as temperature, pollution, plant growth, sea life and much more. With measurements comes the opportunity to take action, driven by new and precise data. In the extreme scenario, we are entering a kind of 'Digicene'. Just as atmospheric scientist Paul Crutzen has popularised the word Anthropocene to mark an epoch when human activities started to have an impact on the Earth's ecosystems, it is not too fanciful to imagine it being displaced by the Digicene, an age when digital technology catalyses change across the physical world. The sustainability potential of this can hardly be over-stated.

It is our expectation (even intention) that this document will raise more questions than answers, so if you have any comments on this topic (or any other), we would be delighted to hear from you.

A handwritten signature in black ink, appearing to read 'Patrick Sheehan'.

Patrick Sheehan, Managing Partner

# Internet of Things: the essentials

## Terminology

As with any new concept, terminology can be the first barrier to wider comprehension. In this document, we use 'Internet of Things', because it seems the most common (if not exactly greatly 'popular') term, but there are others, including 'the smart connected world', 'ubiquitous computing', 'embedded intelligence', 'Connected Everything' and 'Industry 4.0'. When the IoT was less of a 'thing', technicians commonly referred to it as 'Machine-to-Machine'.

## What is the IoT?

It is networks of internet-connected physical objects, typically with embedded sensors, that connect the real physical world directly into existing computer networks. To be of use, this data must be secured, analysed and in some way 'actionable'.

## How is it different from the world-wide web?

Objects, not people, sit at the ends of this network. They do not consume large amounts of data, but generally only generate it, and in the main (individually) do not even do that much. While each thing will need to be cheap and simple, collectively the power of many things can be enormous. There is a handy acronym to remember its distinguishing features, courtesy of Goldman Sachs: SENSE: Sensing, efficient, networked, specialized, everywhere.

## Why is it happening now?

*"In a few decades time, computers will be inter-woven into almost every industrial product."*

*Karl Steinbuch, German computer scientist, 1966*

Although the term Internet of Things is believed to have been coined in 1999 (by Kevin Ashton, a British entrepreneur), its wider adoption has had to wait for the availability of various technologies at affordable prices. These include huge advances in computer power; 'big data'; ubiquitous broadband communications; as well as sensor and battery technologies. This convergence of multiple technologies means the infrastructure is in place or arriving fast. The challenge now is to intelligently apply this potential.

Legend has it, in 1982, a Coke machine in the Computer Science department at Carnegie Mellon University was the first everyday machine connected to the early internet. The vending machine would provide caffeine-deprived coders with information as to its inventory and the temperature of the beverages. It was several decades until Elstat, an innovative company backed by The Environmental Technologies Fund, developed a similar application, but on an industrial scale, with customers such as Coca-Cola.

### Why is it important for investors?

IoT is not just a new sector within the traditional tech sector. It is going to permeate every industry: automotive, healthcare, manufacturing, energy, consumer... It will therefore change business practises and processes in most companies, and do so in a fundamental way.

Another way of thinking of the potential of IoT is within 'settings', as proposed by McKinsey, such as the home, offices, factories, vehicles, the human body etc.

McKinsey estimates the IoT's total potential economic impact at between \$3.9 trillion and \$11.1 trillion per year in 2025 or 11% of the world economy (based on a World Bank GDP projection for 2025). Meanwhile, a study by Harbor Research suggests the cumulative revenue from smart systems could rise from \$247.5 billion today to up to \$926.5 billion by 2020.

According to BI Intelligence, nearly \$6 trillion will be spent on IoT solutions in the next five years.

More prosaic but still telling, is the number of things connected to the internet. In the late 1990s there were around one billion people connected, and this doubled during the 2000s. Professional forecasters are saying that in 5 years' time there will be 25 to 40 billion things connected. Everyone is guessing to some degree, but it is clear that the numbers will be very large.

Businesses look likely to be the main top adopter of IoT solutions, initially. They see three ways the IoT can improve their bottom line by:

- Lowering operating costs
- Increasing productivity
- Expanding to new markets, developing new product and service offerings that were not viable before

Governments are focused on increasing productivity, decreasing costs, and above all improving their citizens' well-being - while reducing healthcare costs and at the same time increasing quality of life. We believe they will be the second-largest adopters of IoT ecosystems.

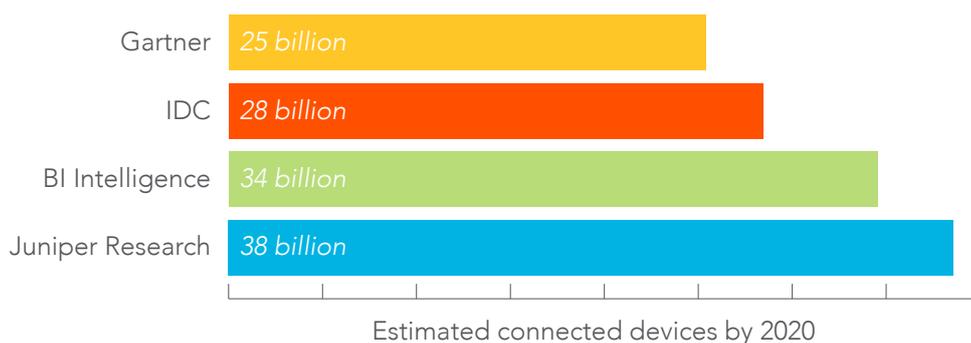
Consumers will lag behind businesses and governments in IoT adoption. Still, they will purchase a massive number of devices and invest a significant amount of money in IoT ecosystems.

Clearly, all such estimates should be treated with caution, but we are talking big numbers.

## "IoT's economic potential could be as high as \$11trn by 2025"

*McKinsey & Company*

Figure 1 - Connectivity predicted



### Is it hype?

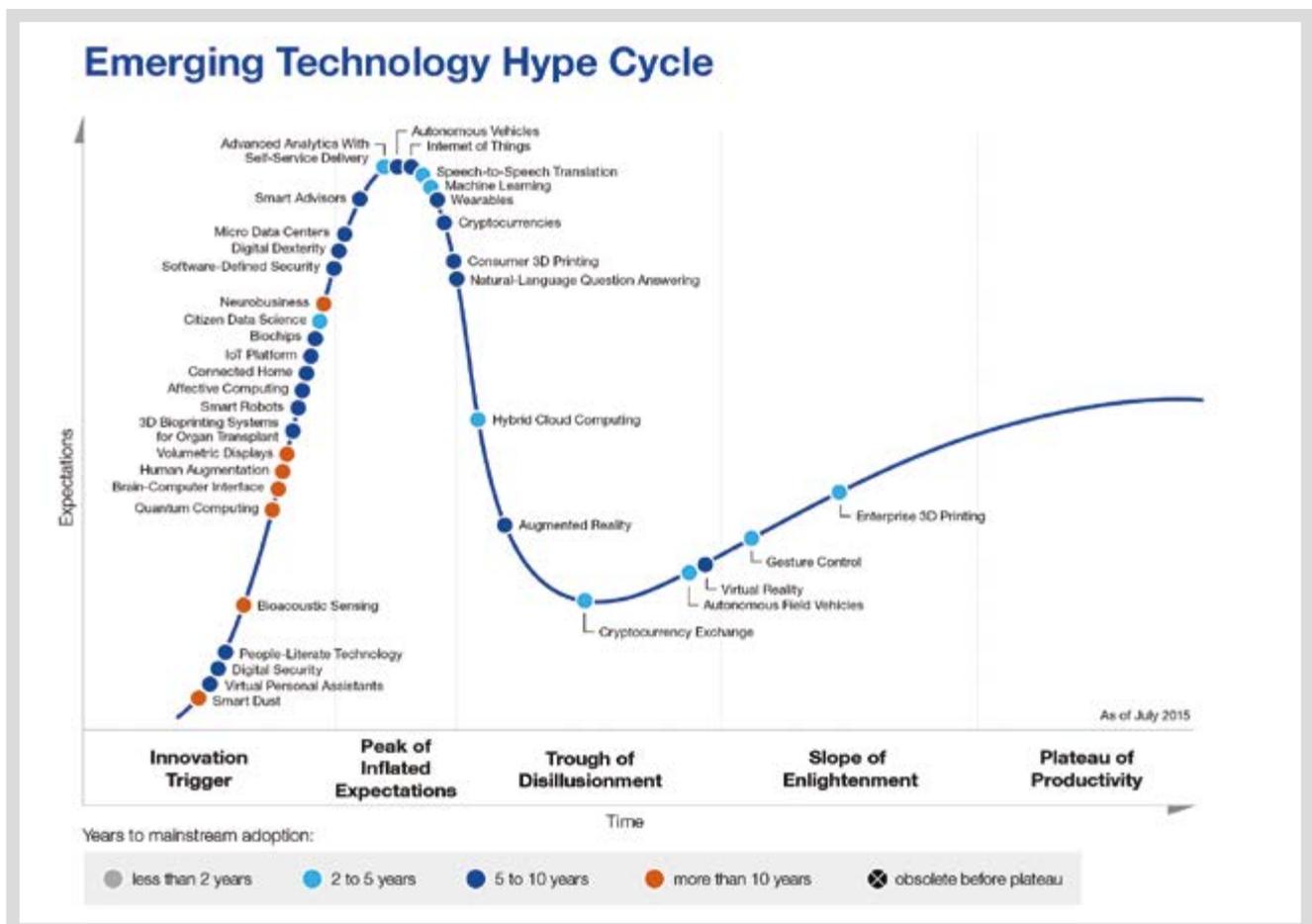
IT research firm Gartner - in spite of forecasting 25 billion connected things in 5 years' time - positions the Internet of Things as moving towards the peak of its famous 'Hype Cycle' and predicts the 'Plateau of Productivity' as being five to ten years out. Sceptics point to remaining challenges and in particular to a lack of profitable and proven IoT business models. Others are no doubt simply 'put off' by the audacity of claims.

Klaus Schwab, founder of the World Economic Forum in contrast, wrote in January 2016, of a fourth and distinct industrial revolution: "when compared with previous industrial revolutions, the Fourth

is evolving at an exponential rather than a linear pace. Moreover, it is disrupting almost every industry in every country. And the breadth and depth of these changes herald the transformation of entire systems of production, management, and governance."

Our view is that by the time this argument is over, the opportunities will have been seized. We look for themes that have the potential to shoot the lights out, and IoT clearly qualifies. But we are also grounded in what makes business sense today. Our IoT investments are in post-revenue companies, some of which are already profitable, and they all stand to make significant environmental contributions.

Figure 2 - Gartner Hype Cycle



# IoT and Sustainability

The COP21 agreement of late 2015 involved a commitment to a global stock-take. Collecting the evidence and information underpinning climate change and global warming is an essential and non-trivial part of managing global temperatures. This commitment was driven by the reality that to have an environmental impact one must monitor the man-made world and the physical world.

As well as the copious efficiency benefits associated with IoT, its “world-sized” potential network means it will be one of the best sources for analytical information that climate scientists need. As Klaus Schwab says, “we are facing a blurring [of] the lines between the physical, digital and biological spheres.” To get to grips with this, we will look at the impact of IoT in three different realms; Smart Energy, Smart Industry and Smart Cities.



## Smart Energy

The most visible sign of change for many of us is the arrival of smart energy meters, or devices that clip onto old meters, that let us see real time information on our energy usage. The next step, of giving us more simple control, to optimise our usage and our own local generation, is already arriving. More exciting though are the prospects for a truly integrated, smart grid.

The energy grids in developed countries are, by design, concerned with reliable production and distribution from large centralised generators. Renewable energy sources change this paradigm. The establishment view has too often been fearful of the intermittent

nature of renewables such as solar and wind, and is only now beginning to take the smart and flexible control of energy seriously. EY reckons a smart energy grid reduces energy costs by around a third<sup>2</sup>.

By 2025, digital technology may define the electricity system almost as much as physical engineering, according to a report by the UK Government’s Chief Scientific Adviser. The report says that the IoT could ‘redefine’ the UK’s existing system. Meanwhile a study by AT&T<sup>3</sup> estimates that machine-driven energy management could reduce greenhouse gas emissions by 9 billion tons of CO2 equivalent by 2020, almost a fifth of the total.

## Smart Energy Innovator

**The business:** 4energy

**IoT app:** low energy cooling

**HQ:** Nottingham, UK



One of the critical issues of our time is to reduce the amount of energy we consume. To do that, we need better insights into how we use energy today, as well as the ability to eliminate waste. 4energy is an IoT company, which supplies intelligent monitoring and controls software that connects back to utilities’ central operations through a family of interconnected sensors. Using 4energy’s Smartset software, companies can cut costs significantly by reducing HVAC (Heating, Ventilation and Cooling) spending.

The company was founded in 2005, and under the leadership of Pat Tindale, has grown from its core UK base to operate across EMEA, India and China. It has installed solutions in over 15,000 sites for telecommunications, utility and rail customers worldwide. The UK utility, British Gas, is an investor in the company and a leading partner. ([www.4energy.co.uk](http://www.4energy.co.uk))

2. ‘Smart Grid: a race worth winning?: a report on the economic benefits of smart grid’, Ernst and Young, 2012  
 3. Machine to Machine Technologies: Unlocking the potential of a \$1 trillion industry, 2013



## Smart Industry

A recent headline in the Economist says, "Manufacturers must learn to behave more like tech firms<sup>4</sup>." As components as well as end-products within the value chain become 'smart', there will be a shift from products to services. This will mean, for instance, a race to develop platforms, the software foundations on which to build services and applications. No company wants to be left building just the "dumb," commoditized matter on which other companies will build value-added services.

Goldman Sachs believes fixed investment growth is moving towards software as opposed to traditional capital goods equipment. This results in a merging of hardware and software and offerings that will 'support better recurring revenues and customer stickiness.'

As with most aspects of IoT, this isn't a theoretical development, but an existing, creeping risk, that smart companies (and countries) are already addressing. In 2011, Germany launched "Industrie 4.0", a government initiative to promote the computerisation of manufacturing.

Nobody wants to build the "dumb," commoditized matter on which others build value-added services.

In March 2016, a US senate bill was proposed, titled the 'Developing Innovation and Growing the Internet of Things Act (DIGIT Act)'.

A study by MPI Group found that 76% of manufacturers intend to increase their use of smart devices within two years in order to improve customer satisfaction (76%), productivity (75%) and quality (72%). On the other hand, few had the internal networks capable of integrating such systems.

## Smart Industry Innovator

**The business:** Perpetuum

**IoT app:** wireless sensor networks

**HQ:** Southampton, UK



Before Perpetuum, rail engineers had to suit up and physically inspect the integrity of train wheels. Now they don't have to leave the cabin. Fantastic, but what has that to do with the IoT, you may ask?

Perpetuum's unique power source harvests energy from vibration on the line, and converts them into an electrical power, providing self-powered wireless conditioning monitoring solutions for rail networks (and perpetual power for wireless industrial automation applications, generally).

In so doing, the company has revolutionized the way large amounts of information can be gathered - perpetually - from maintenance-free wireless sensor nodes. Not only can trains now 'speak' to technicians, real-time about their integrity, but they can also provide a real time 'map' of the entire rail network. Perpetuum supplies companies such as Network Rail, ScotRail, Swedish Rail (SJ), GoVia, Keolis-Amey, Metro Trains Melbourne, GVB Amsterdam and Eversholt Rail. ([www.perpetuum.com](http://www.perpetuum.com))

4. Economist, November 2015



## Smart Cities

For evidence of the IoT around you, look no further than the world's smartest cities. As complex, organism-like networks, cities have proved highly receptive environments for IoT applications.

As long ago as 2010, the European Union chose the Spanish city of Santander as a test bed for smart city technology. A whole host of innovative solutions were implemented, from improving the city's rubbish collection to more efficient use of its sprinkler systems. As a collective result of these and other smart city systems, Santander claimed to have reduced energy usage by as much as 25%.

Smart city technology can also be used to benefit cities in other areas. In Amsterdam and Dublin, publicly accessible databases have been established that share information collected from smart city technology. The goal is for entrepreneurs to come to the city and create products that use this data. In this way, smart city technology is being used to promote new business initiatives, while improving services for its citizens.

From a sustainability investor's point of view, the IoT offers the prospect of completely new businesses and business models. Take for instance the ability to control light or air pollution. This can only be addressed by large distributed networks - networks that have to be far cheaper than traditional wireless networks in order to be economic.

If that sounds like a tall order, then look at the success of Telensa, a UK-based company backed by The Environmental Technologies Fund, which has already delivered a network of more than a million smart street lights. Telensa is interesting not just because it is an example of a profitable IoT company operating globally, but also because it can use its previously deployed infrastructure to deliver new services, such as temperature sensing (when to send out the salt gritting trucks), traffic monitoring and air quality tests. Indeed, Telensa has already deployed a Smart Parking solution in cities from Moscow to Shenzhen.

### Smart Cities Innovator

**The business:** Telensa

**IoT app:** smart street lighting, parking

**HQ:** Essex, UK



One of the largest deployments of IoT applications to date has been in the area of smart lighting. Many of us are now familiar with the explosion in LEDs, and as part of that trend, municipalities, particularly those in Europe, are moving quickly to deploy smart street lighting based on LED technology.

Telensa makes wireless smart city control applications, including the world's most widely deployed smart streetlight solution. The company has over 50 city and regional networks deployed in 8 countries, covering over 1 million streetlights. Fundamental to Telensa's success is its Ultra Narrow Band (UNB) wireless system, which combines low-cost, long range and long battery life for vast numbers of devices.

Telensa's smart lighting solution pays for itself in energy and maintenance savings, and doubles as a city-wide platform to add a range of "light-centric" IoT applications. Today these include smart parking, traffic monitoring, environmental alerts and citizen engagement. Deployments range from Manchester, to Moscow to Atlanta. ([www.telensa.com](http://www.telensa.com))

# Technical challenges

## The big technology challenges... and more investment opportunities

IoT's great potential is driven by a confluence of technological advancements. The cost of sensors has fallen by more than half in ten years; the cost of bandwidth has fallen by a factor of forty and the cost of processing by a factor of sixty<sup>5</sup>. In addition, the newest version of the internet protocol IPv6 has capacity for effectively unlimited addresses<sup>6</sup>. However, while the infrastructure is largely in place, effective implementation still poses challenges, often around data analysis and security.

### Very big data - analysis and action

A few years ago people were saying that "90% of all the data in the world was generated in the last two years<sup>7</sup>." Mobile data traffic alone has doubled since then, and clearly there is a 'data explosion'. Increasingly, it is useless without new means to analyse it all. It is estimated that 2.5 quintillion bytes of data are consumed everyday and only about 5% is actionable. As a result, 'machine learning' will be critical to IoT's success.

### Security

Securing the smart grid and physical devices that connect to it is a significant challenge. Some of the factors that have made the IoT possible have also made hacking physical devices easier and more rewarding. Indeed a large amount of the media coverage on 'the internet of things' is associated with consumer security breaches.

According to Dave Chismon of MWR InfoSecurity, hardware for reverse engineering physical devices and radio protocols, and 'software defined radio' (that allows a range of frequencies to be easily communicated) are inexpensive, so the threat is real and growing. Companies now need to assume that hackers - not necessarily maliciously - will attempt to reverse engineer and modify their devices.

However, the real concern is malicious hacking once vulnerabilities have been identified. According to MWR, the security of embedded devices, such as those used in IoT applications, is typically far behind that of full operating systems, which can give the attackers an edge. Securing embedded devices can be complex, with multiple levels of access to a system needing to be secured.

## IoT Security Pioneer

**The business:** MWR InfoSecurity

**IoT app:** network security

**HQ:** Basingstoke, UK



The IoT at its core, is a collection of connected electronic devices, which means both the endpoints, as well as the networks, are vulnerable to hacking. To accelerate the deployment of IoT networks, companies need to address security vulnerabilities and successfully monitor and detect for attacks. MWR InfoSecurity is at the vanguard of developing security solutions to protect, detect and respond, while enabling the rapid roll-out of these networks and devices. Whether it be solutions to secure the smart grid/ smart meters, the electric car/urban transport, home automation, etc., MWR offers secure solutions to companies in these fields. The Company has a top tier list of Fortune 500 companies, with offices in the UK, Germany, South Africa, Singapore and the United States; it is recognized to be a leader in its field. ([www.mwrinfosecurity.com](http://www.mwrinfosecurity.com))

5. Goldman Sachs, Making sense of the next mega-trend, 09/14. 6. Morgan Stanley, the Internet of Things is now, 2014 IPv6 allows has increased capacity for IP address from 4 billion to 340 trillion trillion trillion. The internet's vital expansion, 2007. 7. Science Daily, 22 May 2013.

# Conclusion

“We believe this impact could be transformative, ushering in a new age of the earth.”

From our position as investors looking at a wide variety of IoT-enabling companies, we have no doubt about the scale of change that will occur across a range of industries. We see it as a revolution, like the internet, that is likely to drive extraordinary investment returns, and a revolution in which nimble new companies can and should do well. These beliefs are increasingly shared by the world’s largest industrial companies – some of which see the Internet of Things as not just important, but central to their business models.

The biggest difference between the first internet revolution and this one, is its potential impact on our planet’s physical systems. We believe this impact could be transformative, ushering in a new age of the earth. In this document, we have coined the term Digicene to describe the time when the earth’s geology comes to be affected by technology (see below).

But for all it’s potential, the IoT is only an enabler. It is the entrepreneurs who develop business models that can harness its power – to rapidly increase scale, efficiency, disrupt and fundamentally change the way we organise our world – these are the soldiers of this revolution. The future belongs to them.

## The Age of the Digicene

This a proposed epoch of the earth, following the Holocene which began about 10,000 years ago at the end of the last Ice Age, and the Anthropecene, a term used by atmospheric scientists to cover a more recent epoch when human activities started to have a significant global impact on the Earth’s geology and ecosystems.

We believe we are about to enter the age of the Digicene, whereby digital technology will catalyse and accelerate vast and profound changes across the physical world.

Beginning in the mid-20th century, the Digicene is a combination of digital and the root ‘cene’, the suffix for epoch in geological time.

## About Investor Briefings

Our ‘Investor Briefings’ series covers major industrial trends and innovation-related themes from the perspective of ETF Partners – with a focus on ideas that could transform the sustainability of human activity and in so doing, provide large investment returns. For more information or suggestions, contact [info@etfpartners.capital](mailto:info@etfpartners.capital)

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