CANDRIAM
A NEW YORK LIFE INVESTMENTS COMPANY

Planet Metaverse: Searching for a place to land?

Visibility analysis in Boston, United States, using ArcGIS Urban. Powered by Esri.

APRIL 2023

Marketing communication

About the authors.

Johan Van Der Biest

Senior Fund Manager

Johan Van der Biest, Deputy Head Thematic Global Equity, Lead Manager for the Candriam Robotics and Innovative Technologies Fund, has been managing technology portfolios since 1992. In addition to his long expertise in technology investing, he brings a breadth of financial markets understanding to his portfolios, as he has also co-managed the Candriam Global Demography Fund since 2012. Over the years, Johan has managed or co-managed numerous processes, including equity, bond, and global balanced portfolios.

Johan has been part of the Candriam family and its predecessors since 1992. He holds a degree in Commercial Engineering and a specialisation in Finance from the Catholic University of Louvain (KUL).

Felix Demaeght

Fund Manager

Before joining Candriam in 2018 as Equity Analyst, Felix worked as research analyst at Capital at Work in Brussels since 2015, where he focused mainly on technology and automotive companies. His role extended to presenting to private clients on technology disruption and automotive innovation.

Felix obtained his Masters degree in Applied Economic Sciences at the University of Antwerp and completed this with an Advanced Masters in Financial Markets at Solvay.

Nathaniel Wejchert

Technology Analyst

Prior to joining Candriam as Technology Analyst in 2022, over the previous five years Nathaniel worked in different roles at ING, KPMG, Prime Capital and Degroof Petercam, across Europe. During that time, he built in-depth expertise in the broader technology sector.

Nathaniel graduated from Montpellier Business School, after having obtained his bachelor's degree at Maastricht University.

Table of contents.

Planet Metaverse: Searching for a place to land?

Meta (Greek): with, after, between, among.
-verse: from universe

The metaverse is set to gradually become an integral part of people's lives. It is expected to be used everywhere – from games and shops to science, construction, healthcare and education.

The substitution of reality with the imagined – transporting the user literally into a whole new world – could become possible for all kinds of products and services. For investors, that will mean a wide range of opportunities trying to tackle different challenges and risks, each resulting in different outcomes.

It is perhaps fitting that the Greek word (μετά) chosen to describe this highly diverse emerging area of investment has not one meaning but several: "among", "with", "after". However, as the portal of the Meriam Webster dictionaries helpfully points out, "*we can thank New Latin, the language of scientific nomenclature, for its use prefixing the names of certain disciplines. In its most basic use, meta- describes a subject in a way that transcends its original limits, considering the subject itself as an object of reflection*[1]." In other words, the metaverse was meant to be a world transcending the limits of reality, and yet only as a reflection of reality.

In more simple terms, the metaverse is defined as a digital representation of the real. In this digitally created world, people will be able to connect to everyone and everything in the blink of an eye and take part in immersive experiences that can look and feel very close to real world experiences.

Fantasy becomes reality?

Some may be forgiven for picturing spending their evenings in their rocking chairs and, wearing special virtual reality goggles, "boarding" a virtual plane, or "visiting" the Roman Coliseum, "going shopping" to Gucci for a new outfit for them (or for their avatar), or "going" to a concert of their favourite artist. The metaverse will be a giant mix of real - recordings of what actually took place in the real world - and imagined, with all the content generated by artificial intelligence (AI).

Some of the Metaverse would certainly be pure entertainment. But what it will be able to do and the impact it will have on the economies and societies alike, is likely to be much more wide-ranging and significant.

Chicken or Egg?

Much of the conversation about the metaverse is centred around its entertainment and commerce possibilities. But that, in fact, represents only the tip of the iceberg of the potential monetisation opportunities of this technology. In contrast to its consumer areas, industrial applications represent a huge bulk of the metaverse's development, having laid its foundations over 70 years ago.

The roots of the industrial metaverse go back to long before the age of the Internet, to the dawn of the computer era itself and to Computer-Aided Design (CAD). This term dates back to the 1950s, when science engineers designed some of the earlier graphical display systems for computers. It was a static system, offering a shot in time view, without the ability to see a progression over time. That came a lot later.

Then came an immersive digital reality separate from the physical world - with video games in 1980s. A notable breakthrough for consumer applications came about 20 years ago, when the San Francisco-based firm Linden created "Second Life'', a virtual world inhabited by avatars. As part of this game, people represented by their avatars could interact with other participants, build, create, shop, and trade virtual property and services with one another.

The metaverse technology is already used for a wide range of industrial applications: from design, be it cars or buildings, to infrastructure maintenance, or designing and testing the deployment of 5G.

Digital twins are currently being introduced to the world by many industrial companies. These digital representations of objects and places go a step further than the traditional simulations by also comprising a fourth dimension: time. They are fed by real time data, captured by all kinds of connected sensors that can, for example, measure temperature, air quality or energy consumption. Using a real time digital twin will provide users with an exact digital copy of a real object at any moment in time. In a digital environment, problems can be found, analysed, and fixed before they surface in the real world. This technology can also be used to great effect in a global economic efficiency drive, to stress test and optimise maintenance, traffic, air quality, energy consumption, capacity utilisation or inventory management.

In this paper...

In this white paper you will read about the origins of the metaverse, the basic principles on which it was built, its key applications, and some of the most exciting investment opportunities linked to this technology.

You will learn about how the basic virtual reality technology emerged long before the Internet, and how it has gradually evolved over the years to offer new technological solutions for curing the sick, optimising buildings and machines, and making cities cleaner and more energy efficient.

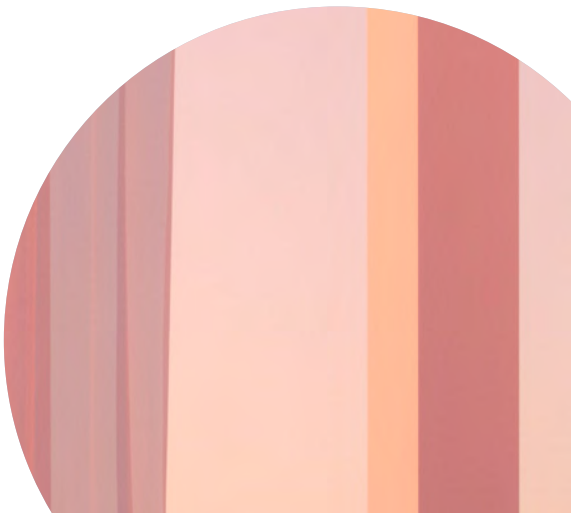
Throughout the paper you will find case studies, examples from the metaverse's history and our view of the future of this fascinating virtual world.

Internet Decentralised: 1.0, 2.0, 3.0!

Just as in the early days of the Internet, the metaverse does not yet exist as one interconnected entity. There are several, independently functioning metaverses centred around different sectors and specific applications, such as defence, manufacturing, education, healthcare, scientific research and so on. The time has not yet come when, as with the modern Internet, users can move seamlessly from one metaverse to another.

One, interconnected global metaverse, not owned by any particular individual or company, is expected to be based on a new decentralised internet, the so-called Web 3.0. There will be a major change in the way all data is held – no longer by large companies such as Meta Platforms or Alphabet but through blockchain technology. This should help to reduce the risks around privacy and the use of data, with blockchain also becoming one of the main creative forces of the metaverse, together with AI and machine learning.

It took over 10 years to transition from the original web, Web 1.0 ("read-only Web"), to Web 2.0 ("the participative social Web"), and it is expected to take just as long, if not longer, to fully implement and reshape the web with Web 3.0[2].

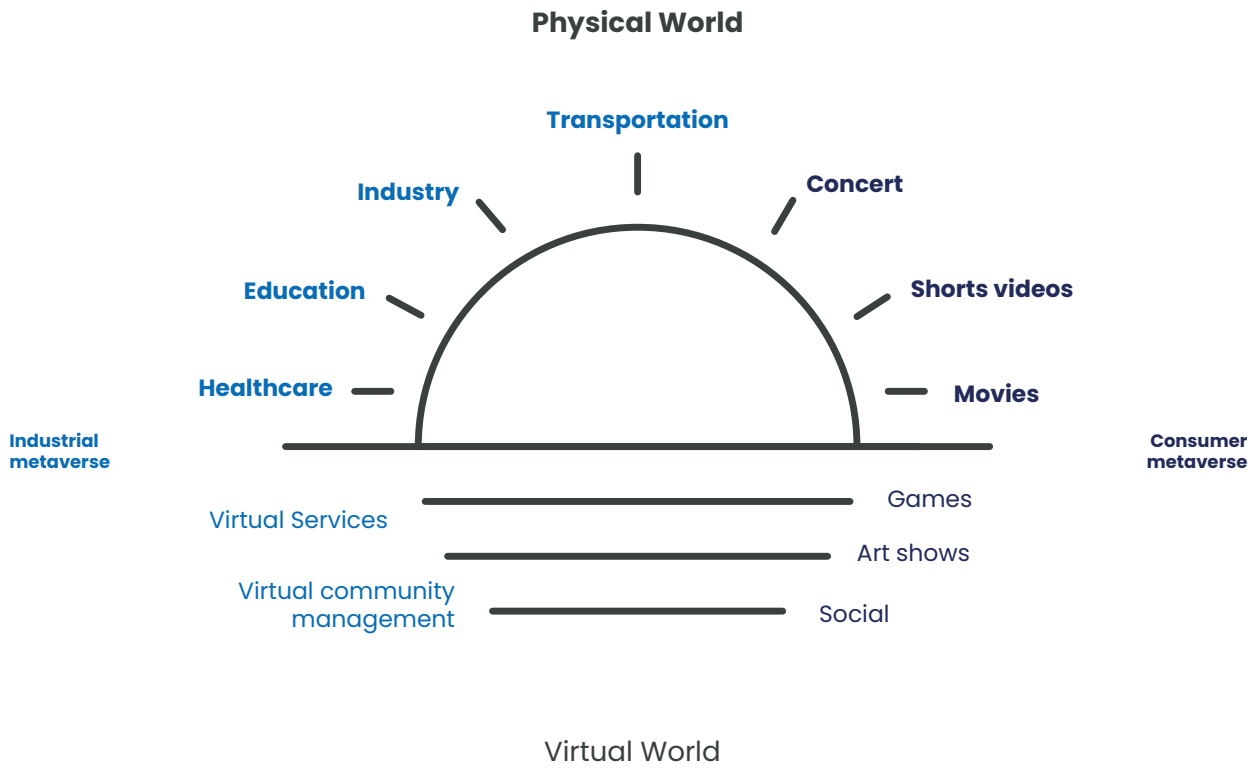


The Many Hats of the Metaverse

As we mentioned, the applications of the metaverse will be wide ranging, spanning many sectors and types of human activity. In other words, the metaverse may do different things for different sectors.

Its functions can be distinguished by what the technology is used to do, for example to visualise, communicate, achieve better collaboration, design, operate, investigate, entertain, or help transact. Then there are the so-called "verticals", i.e. where metaverse applications are used in a particular context, such as a sector, industry, or specific project, such as the healthcare vertical, or infrastructure vertical.

Figure 1:
The metaverse: Industrial and Consumer



Source: Deloitte Research and Analysis

Managing expectations

At an abstract level, the core objective of the metaverse is to enhance the immersive experience of our interactions with technology in all its forms, further bridging the gap between digital virtual reality and the real world itself.

In practice, this entails further dissolving the human-machine interface divide. Innovations of the last 20 years, including haptic screens and artificial intelligence capabilities, have made user experiences considerably more seamless, but there is still a disconnecting psychological barrier between the end user and the digital content they are interacting with.

Nevertheless, there will be easy low hanging fruit that the metaverse can pick with great effect. For example, videoconferencing has been instrumental at keeping businesses going throughout the Covid-19 pandemic, and "virtual" meetings continue to play an important role as partial working from home becomes the norm. The metaverse will help further blur the divide between being at the office or working from home. That said, as a parallel experiential dimension, the metaverse is intended to enhance the physical world, and our actions and decisions taken there, rather than replacing it.

Verticals:
Use in Different Sectors

In the **architecture, engineering and construction ("AEC")** verticals, digital replicas which store and stream an accurate digital version of underlying physical assets – such as buildings, pieces of machinery, or electrical grids -- are being created to enable better communication and collaboration between stakeholders (across the construction lifecycle of a skyscraper, for example) and to improve operational processes (such as tracking real-time throughput efficiency of an industrial plant). Metaverse technology has also been used successfully in the restoration work carried out on the Notre Dame Cathedral in Paris, which suffered very significant fire damage in April 2019, making headlines worldwide. A full-scale, interactive digital twin of the cathedral was created for architects, engineers, and historical experts to consult along the process. It brought together a wealth of information about the structure, from construction sketches to 3D scans of its current state and will build upon new data and information as the restoration work continues[3].

Digital Twins: Cornerstone of the Metaverse Vision

The digital twin is a digital, synchronised replica of an underlying process, system or asset. This is achieved via a continuous stream of real-time data (emanating from various sources, such as existing databases or Internet of Things (IoT) devices such as cameras, lasers, and sensors) that is fed into the digital twin and produces an interactive, observable output. Digital twins are therefore distinct from simulations. In contrast to a simulation, whose aim it is to predict the behaviour of a process, system or asset, a digital twin seeks to provide an accurate impression of what is taking place in real-time. In the metaverse, digital twins and simulations -- will work in tandem to provide immersive, interactive experiences.

The digital twin concept, supplemented by simulation capabilities, can be used in a huge variety of scenarios.

Anything from smart cities and mobility patterns in the infrastructure sector (vertical), 3D virtual stores and showrooms in the retail vertical, to electrical grids and fusion reactors in the energy vertical. Indeed, it is harder to identify industries where digital twin technology won't add value than where it will.

For example, a digital twin of a car would entail a virtual replica of the entire chassis, software, power train, electrical system, brake system, as well as the physical behaviour of the vehicle. This virtual replica would require data from sensors on real-time and past performance, inspections, as well as service history, configuration changes, parts replacement and warranty data. In turn, this digital twin could help car vendors streamline maintenance and improve their customer service.

Digital twins will also be an important part of the connective tissue of the metaverse. Digital twins will be interconnected through digital twin super-systems that interact with each other.

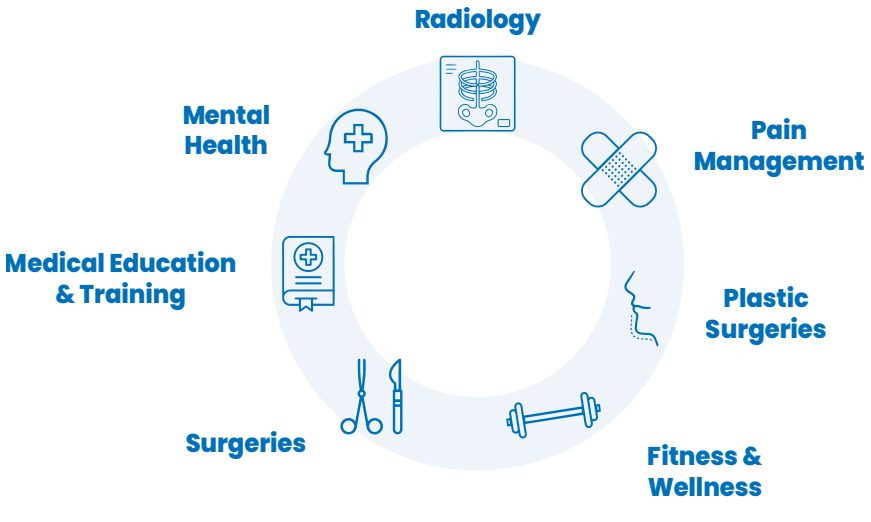
Taking it a step further, entire cities or supply chains could be mapped with the use of digital twins, providing detailed ongoing insights into very complex structures. Similar to how the internet is network of websites, the metaverse can be viewed as a network of 3D digital twins, with other functions and capabilities overlayed on top of it.

Figure 2:
Point cloud of the Notre Dame Cathedral in Paris generated from the 3D digitisation campaigns conducted by Art Graphique & Patrimoine (AGP) before the fire.

Source: Art Graphique & Patrimoine

In the **healthcare** vertical, applications span a very comprehensive range of specific uses. Investigative and entertainment applications could give medical students, patients and other users the ability to explore and interact with informational hologram renderings of human anatomy. They can be used to learn about and stress-test fitness and health goals or pathologies, or anticipate potential injuries, and train surgeons. Immersive environments can help doctors to explain, and even show, disease states and treatment plans. Combined with haptics[4], extended reality and artificial intelligence, digital twins could be used for diagnostic purposes or further detailed investigations, as well as pre- and post-surgical interventions.

Figure 3:
Key metaverse applications in healthcare

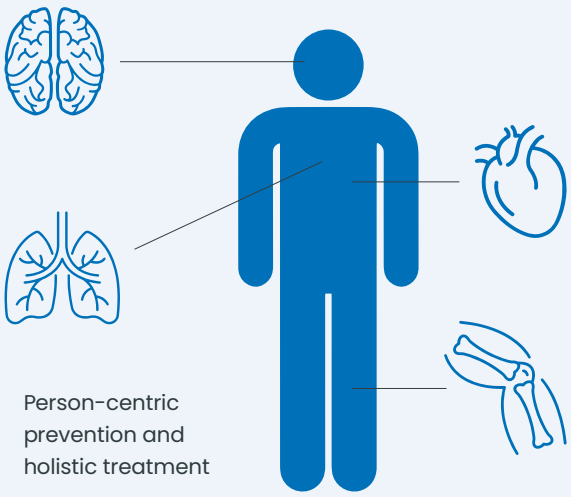


Source: Candriam

Making History 1:
Digital Twins in Healthcare

There are many different types of digital twin-based systems that are being developed and tested. Most of them will incorporate AI capabilities to model morphology delineation and conduct interpretation (e.g., localisation, volume and shape of organs, or a cancer tumour for example; delineation of the liver vessels, liver volume and shape), which is achieved using an AI-powered inference.

Figure 4:
Digital twin in oncology: the most frequently examined organs of human body



Source: Siemens Healthineers, February 2023

To create a digital twin, **data is first taken from a wide range of patients to train the AI models** offline that work together to build the Digital Twin. It includes contouring of the main anatomical elements of the body (or, as shown in Figure 4, of the knee and knee vicinity, such as cartilage, ligaments, bones, and muscle) and key indicators related to them (such as the strain and stress distributions experienced by the knee structures, and the knee motion). Other input data may cover stress tests of virtual interventions or surgeries (such as cartilage repair, anterior cruciate ligament reconstruction, and motion optimisation).

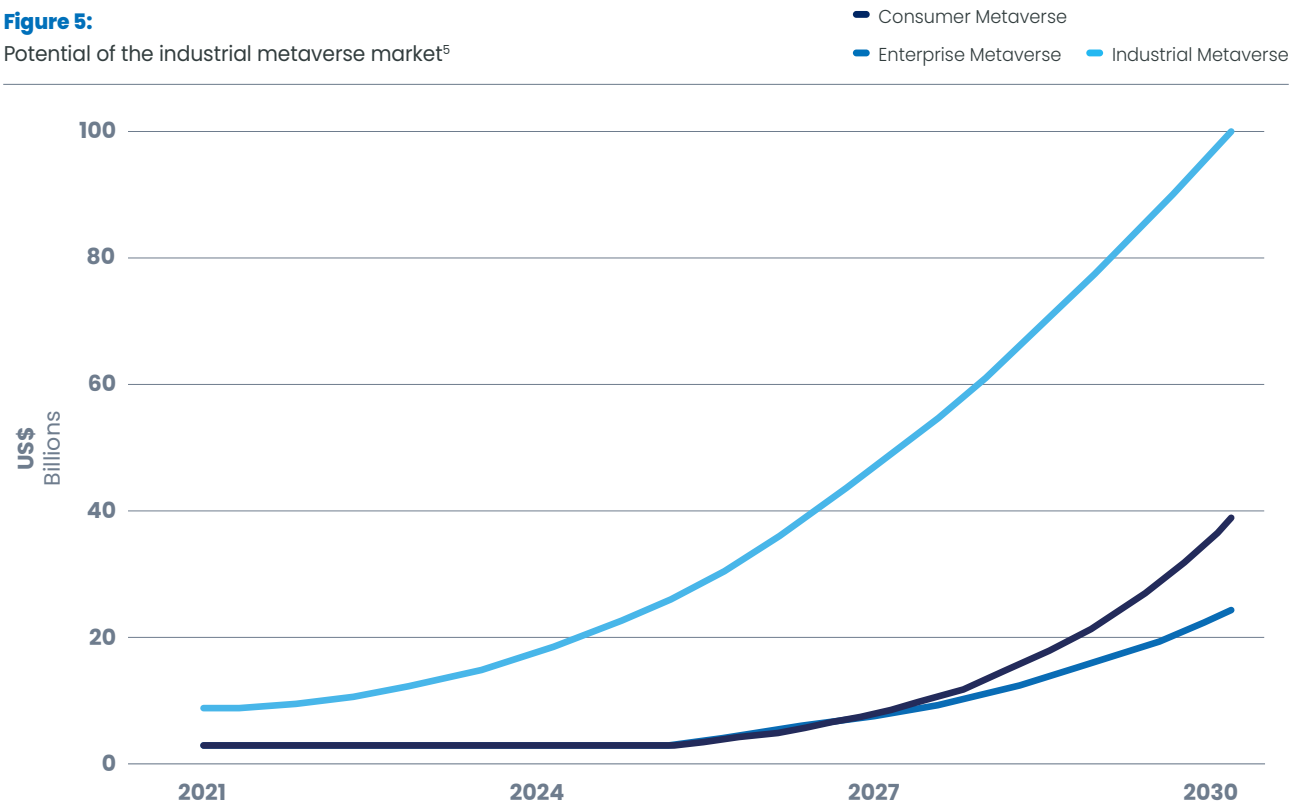
Second, the model incorporates all the necessary data from the specific patient. The closer the digital twin simulates the patient, the better it is for diagnostics, planning, optimising and execution of various treatments.

In the **manufacturing** vertical, the re-creation of real-world systems in a virtual environment will enable manufacturers to improve their supply chains and increase their overall operational performance. By leveraging the metaverse, manufacturers will be able to construct virtual factories that monitor production lines and assembly lines in real-time as well as train employees on remote maintenance, equipment management, quality assurance and more. It will also enable manufacturers to test their products quicker, creating a virtual community wherein designers and engineers can share, discuss and fine-tune pre-prototype ideas.

We gave just a few examples of how the metaverse can be used for different industrial applications. It is difficult, if not impossible, to be exhaustive and try to present a comprehensive picture of how the metaverse will be employed within economies. First, the range of applications is virtually endless. Second, as has proven to be in the case of the Internet, it is difficult to predict how the trajectory of the metaverse will develop and evolve with time, particularly as more people start to interact with it. All we know is that it will change and evolve rapidly, driven by advances in technology and its growing popularity.

How big will it be?

Figure 5:
Potential of the industrial metaverse market[5]



Source: ABI Research, Evaluation of the Enterprise Metaverse Opportunity, Third Quarter, 2022

Estimates for the total market size of the metaverse vary wildly and depend greatly on what is or isn't included in the calculation and what approach is used. For example, to take one such estimate, the total metaverse market could reach USD 800bn in size by 2024, representing a ca. 13.1% compounded annual growth rate from 2020[6]. This estimate covers live entertainment, gaming (software, services and ads), social media ads, and Gaming and AR & VR Hardware.

Making History 2: Building the Industrial Metaverse

In June 2022, Siemens and NVIDIA said they are collaborating to enable the Industrial Metaverse and increase use of AI-driven digital twin technology that will help bring industrial automation to a new level.

In the Industrial Metaverse, companies of all sizes will be able to employ digital twins with real-time performance data, create innovative industrial IoT solutions, leverage actionable insights from analytics at the edge to the cloud, and tackle the engineering challenges of tomorrow by maximizing the accessibility of visually-rich, immersive simulations[7].

In contrast, the McKinsey estimate is based on a bottom-up view of the consumer and industrial uses of the metaverse, as well as on expert interviews. This estimate maintains that the metaverse could generate between USD 4 trillion to USD 5 trillion by 2030. McKinsey expect this roughly 50% compounded annual growth rate (CAGR) in total economic value between now and then to be driven by a confluence of factors, positing that the metaverse's appeal "spans genders, geographies, and generations". In their assessment, consumers are ready to spend on digital assets and are open to adopting new technologies. McKinsey found evidence of companies investing heavily in the development of metaverse infrastructure, and brands experimenting in the metaverse are reporting positive consumer feedback.

Jam (TAM*) today?

According to ABI Research, revenues for industrial digital twin and simulation and industrial extended reality will hit USD22.73 billion by 2025 as organisations use Industry 4.0 tools such as artificial intelligence (AI), machine learning, edge computing, and extended reality to accelerate digital transformation.

*** TAM is Total Addressable Market - also called total available market, is a term that is typically used to reference the revenue opportunity available for a product or service.**

Ultimately, while such forecasts are interesting, we also think that they are inherently fragile and put an artificial cap on the potential market opportunity of the metaverse. For example, we think it is conceivable that many (if not all) verticals outside those used in the Bloomberg Intelligence calculation will form part of the metaverse market opportunity. And although McKinsey uses a much wider perspective for its assessment, we think the metaverse could be more transformative than even what they envision. On this point, we think the Internet and its impact on the global economy provide a better vantage point from which to appreciate the true scale of the metaverse. Indeed, the Internet -- from the fairly primitive form in which it had emerged in the 1960s and all the way until today -- has effectively transformed all aspects of the global economy (whether directly or indirectly), making its so-called total addressable market nearly incalculable. Therefore, we think that providing a numerical estimate of the size of the metaverse is bound to prove inaccurate. Much more sensible would be to assert that the metaverse could be as big or bigger than the total market impact of the Internet. In simpler terms, the market opportunity of the metaverse is potentially enormous.

Cruise Control: Controversies and Sustainability Issues

The metaverse is set to inherit many of the sustainability risks and controversies that are currently linked to social media, gaming industry and, by extension, to the concerned technology companies. However, in some respects the metaverse may offer surprising sustainability solutions. That said, given the sustainability risks and opportunities which the metaverse presents, it is up to investors to find the right risk/return balance and, given the rich diversity of opportunities in this area, we believe this is well within their grasp.

From an **Environmental** angle, the metaverse's digital applications will require a significant energy boost, in turn resulting in higher greenhouse gas emissions (GHG) if the energy they use does not come from renewable sources. Some commerce models currently being established around the metaverse are particularly energy intensive. Today, one single Bitcoin transaction in 2022 could equal over a million of VISA card transactions, consuming about 2,188 kWh[8]. The average NFT transaction produces 48 kilograms of CO2, which is

equivalent to burning 18 litres of diesel[9]. But there are some good signs that this issue is being resolved. For example, in September 2022, the Ethereum cryptocurrency changed from a Proof-of-Work to a Proof-of-Stake[10] consensus mechanism, drastically reducing the energy intensity of validating a transaction[11]. Previously, one single blockchain transaction of Ethereum equalled the energy consumption of more than several thousands of VISA card transactions. Today one transaction consumes just 0.03 kWh (as at 29.11.2023)[12]. This evolution proves the ability for metaverse players to improve, but do they really wish to do so? This is our role as investors to make sure they are on the right path. On the positive side, the metaverse can potentially lead to substantial reductions in carbon emissions, whether through digital products replacing their physical alternatives or new solutions for optimisation our consumption, making our societies more efficient in using natural resources.

From a **Social** point of view, there are concerns around potential gaming addiction, unauthorised access to adult content, gambling, cyber criminality, data protection & privacy, as well as user protection that need to be monitored very closely. There are increasing regulatory risks too. For example, a fairly recent scandal around Cambridge Analytica's illegal use of Facebook has given rise to concerns that social media businesses can get away with crimes that have serious consequences on societies. Cambridge Analytica harvested Facebook data on users and all their friends to use military software for pinpointing psychological vulnerabilities of particular voters. Using targeted false claims campaigns to swing their votes, first in the Brexit Referendum in the UK and then in the US elections, the outcome of which ushered in the presidency of Trump[13]. Another concern is around the potential of AI-produced deep fakes and mind manipulation that can be weaponised to subvert democracy.

"As with investments in any innovative solutions, pursuing the potential of the metaverse must be firmly aligned with better climate and social outcomes.

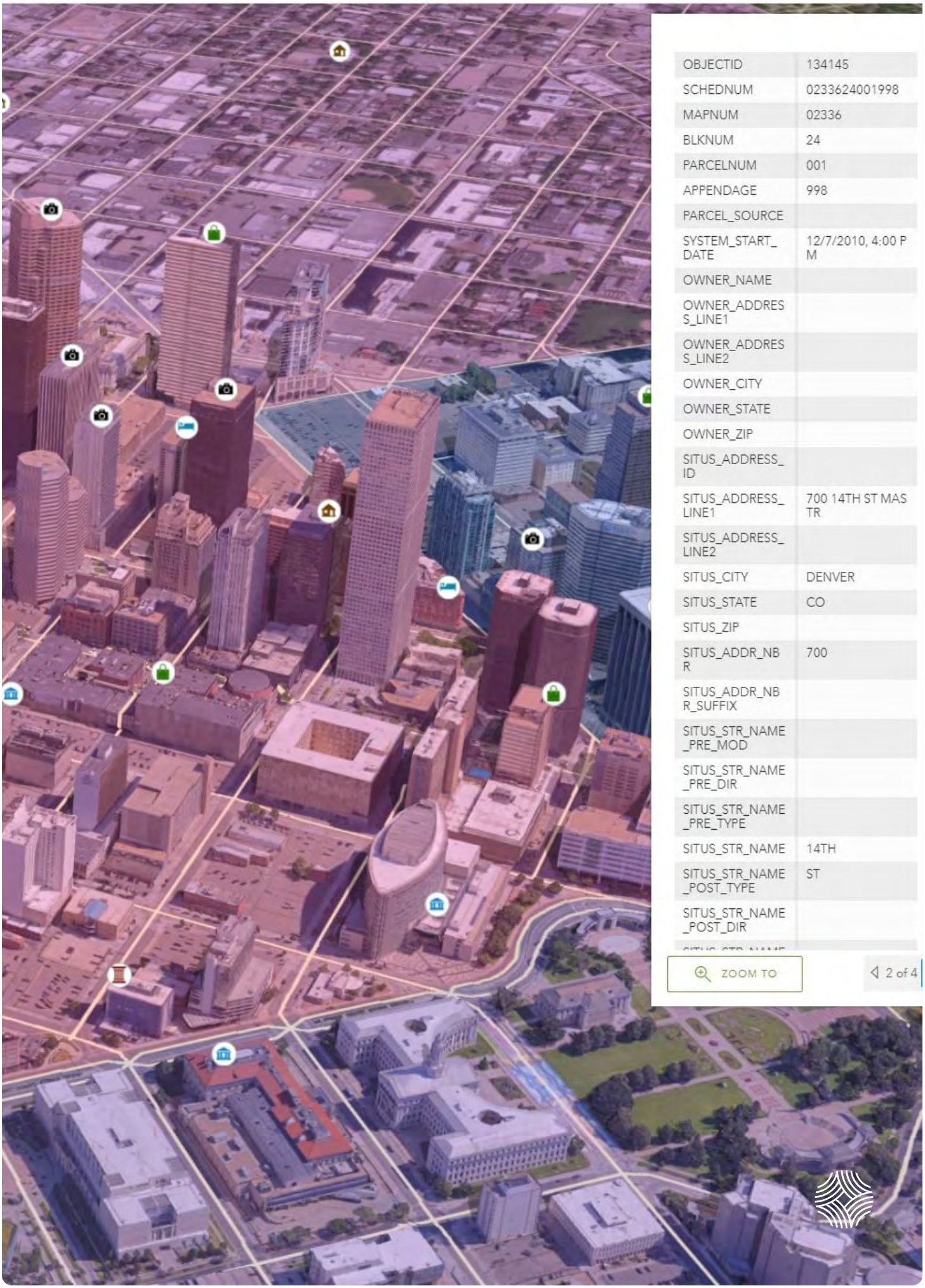
However, we believe that by supporting some of the more promising industrial applications and minimising their exposure to consumer applications investors can avoid and drastically reduce exposure to these risks.

And finally, **Governance** for many technology companies that are involved in the metaverse, is still subject to improvement. These companies often have controlling shareholders with complex ownership structures, or urgently need an efficient board oversight and independent committees to ensure correct behaviour versus all the stakeholders (investors, employees, clients, environment, society, suppliers).

We firmly believe, however, that all of these controversies are and will be tackled going forward, as engagement with these companies is starting to have a benign impact on most of the controversies described above.

As with investments in any innovative solutions, pursuing the potential of the metaverse must be firmly aligned with better climate and social outcomes. We must take a wider view to focus on those metaverse opportunities that bridge the gap between the costs and benefits of utilising the metaverse.

GIS information overlaid on Aerometrix 13S mesh for Denver, United States, provides a powerful web dashboard for cities. Image supplied by Aerometrex. Powered by Esri.



Investment Opportunities

The emergence of Software-as-a-Service (SaaS) models, such as those adopted by companies such as Salesforce or Workday, and the rapid growth of cloud platforms such as Amazon Web Services, Microsoft Azure and Google Cloud Platform have been very good predictors of how to think about applications and the infrastructure on which they run independently. The ability to detach ever-increasing computing, storage and networking power from a physical form factor and move it from an on-premise setup[14] to the internet (basically data centres full of server racks) has created a completely new ecosystem of applications with enormous potential. Seeing how consistent innovation in the underlying backbone drives flexibility and scalability in the application layers opens up opportunities not only to consumer and users but also to investors. Similarly, we expect to see a similar investment thesis for the metaverse where a large part of how fast ground-breaking applications will reach us hinges on innovation in the backbone.

In times when capital has become more expensive, large multinationals must prioritise and rationalise some projects over others. For example, Disney, which is currently restructuring under new leadership, have halted their metaverse plans.

In most cases on the consumer side, metaverse projects offer very little direct return on capital and that's the main reason why, in the currently difficult market environment, several companies have frozen their metaverse-related activities.

In contrast, that trend has not manifested itself on the industrial side (digital twins) – we have not seen any major projects that have been cancelled or stopped. If anything, Nvidia's CEO Jensen remains very vocal about the opportunity of their Omniverse platform and the collaborations they have.

Looking at this from a long-term perspective, we actually think that this will have a positive impact on the broader metaverse ecosystem. Over the last couple of years of cheap finance, investors have not been very discriminate in supporting all kinds of metaverse projects, including some that have been widely regarded as unsustainable, involving cryptocurrencies, NFTs and some metaverse applications. The tightening market conditions have added discipline to the market, helping to direct resources only to the most rewarding projects over the long term.

Metaverse backbone

- **Compute, storage and connectivity**: Data is already proving to be a significant challenge today. But the need to transport, process and store exabytes of data will exponentially increase as we move through different stages of the metaverse. This entails storing complex 3D models, processing completely virtual settings possibly the size of cities or larger and requiring near-zero latency while doing it all.
- **Virtual and augmented reality**: The metaverse banks on the premise that physical worlds and virtual worlds will continue to converge. Today, we need devices to help us bridge the gap between those two worlds of which VR goggles are the most prominent, but the way we connect to the metaverse will undoubtedly change as we progress along the learning curve.

- **Blockchain**: Some instances of virtual worlds are running on centralised infrastructure, and some are running on decentralised infrastructure, i.e. the blockchain. One example is Fortnite that runs on the centralised servers of Epic Games. Another example is Decentraland which is run in a decentralised way on the Ethereum blockchain. As the metaverse is developing both are viable alternatives with each having their distinct advantages and disadvantages.
- **Security**: Security often already is one of the key strategic priorities. As the metaverse will drive a boom of data generation, the potential for actors with bad intentions to abuse that data also goes up tremendously. Additionally, identities at the core of someone's virtual expression in the metaverse (often in the form of avatars) will also need to be strongly secured.

Metaverse applications

- **Consumer applications**: With vastly popular games such as Fortnite and worlds created in Roblox, online game platform and game creation system, the gaming industry has a strong natural fit with the metaverse as gaming environments depart from a 3D virtual world. Artists such as Post Malone, Ariana Grande and even The Foo Fighters have also found their way to the metaverse where they gave concerts to their fanbase.
- **Industrial applications**: We addressed the opportunity in digital twins earlier in this paper. Adding to that, we see the potential for virtually designing meeting rooms and collaborative spaces in which colleagues work with each other much more interactively. Lastly, customers support could be revolutionised with companies virtually showing their clients how to fix or address certain issues.
- **Educational applications**: We have seen how flight simulators are used to train future pilots. Now, we are witnessing how solutions are helping surgeons to be remotely trained, how a welding company uses VR tools to train its welders. In general, the metaverse will have the ability to open up education to a much broader audience.
- **Virtual commerce**: Nike and Gucci have already made headlines with their stores in the metaverse where they sold digital versions of their products in the form of NFTs. Brands and companies will have the ability to greatly increase their omnichannel presence. The world of NFTs could complement the art market and basically create a whole new world of virtual assets that are non-fungible and unique in nature.

Looking Into the Future 1: Enabling digital twins via Omniverse

Nvidia, a Californian company, is arguably one of the most active and accomplished metaverse developers today. It is a world leader in AI computing and it is already well presented in the metaverse through the Omniverse. Nvidia's Omniverse city-scale digital twins are used to help accurately simulate the interplay between 5G cells and the environment for optimal performance and coverage. Without a digital-twin approach, the interaction between the 5G cells, the environment, and humans and devices that are on the move had to be understood with less detail. Many features had to be field tested only after the networks were already built.

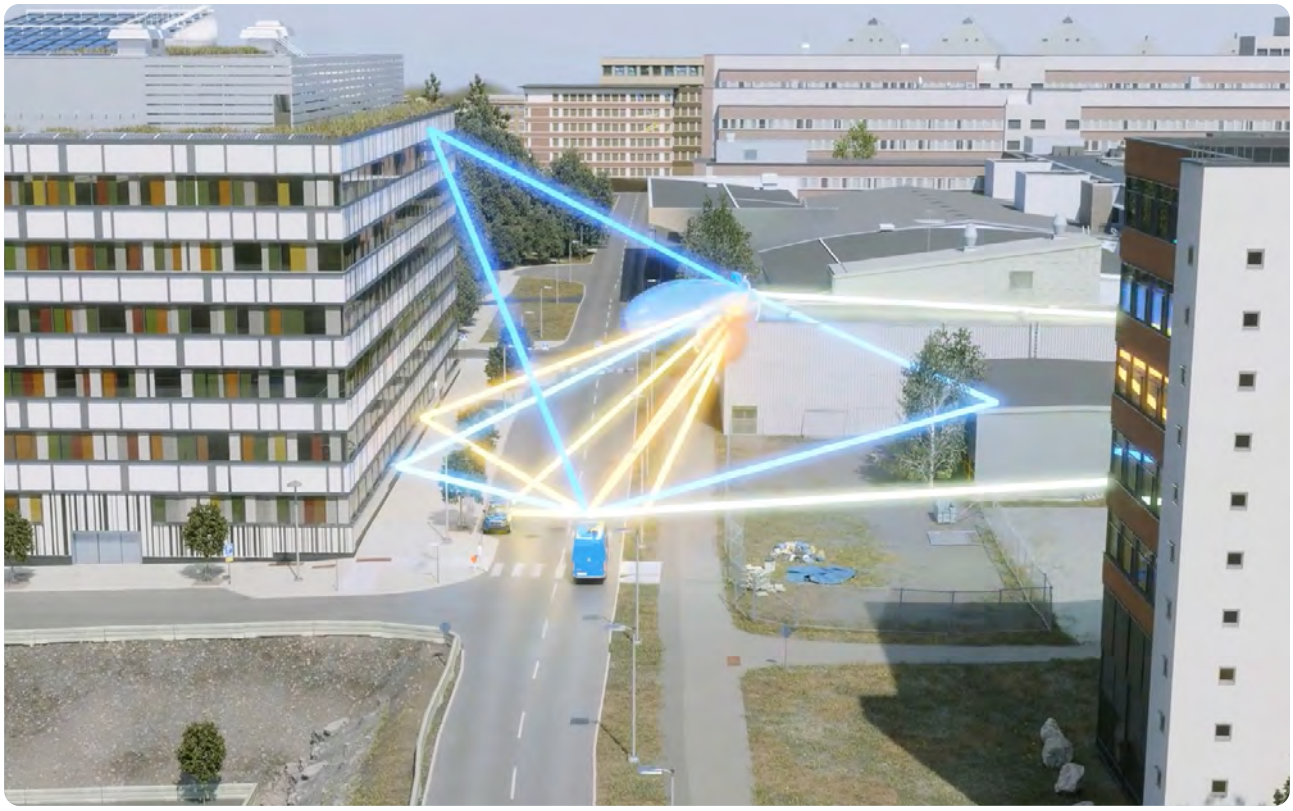


Image Credit: Nvidia

Looking Into the Future 2: Medical training without putting patients at risk

Surgical Science, a Swedish based company, is the leading supplier of virtual reality simulators for medical training. Their simulators are used by medical training centres and institutes worldwide for practice, validation and certification of students, surgeons, and medical doctors.

There are many benefits of using metaverse technology in medical training. It shortens the time it takes to gain competency through consistent cost-effective training that helps to produce better qualified medical professionals.

It also can reduce medical errors and the need to train on patients, while being able to practice a wide range of medical procedures.

Looking Into the Future 3: Creating and operating interactive, real-time 3D content

Unity Software, developed by the US company Unity Technologies, is the leading software engine for mobile gaming, that also helps mobile gaming companies to monetize their content.

While still the biggest chunk of their revenues, Unity starts to expand beyond mobile games. Their RT3D (real time 3D) technology is especially well suited for the metaverse and starts to be a relevant source of revenue. Unity has a partnership with Insomniac (owned by Live Nation) to create metaverse concerts, and they also formed a JV with Endeavor to bring 3D 'metacasts' of UFC matches to fans.

Down the rabbit-hole

> **I can't go back to yesterday because I was a different person then.**
>
> **Alice in Lewis Carrol's "Alice's Adventures in Wonderland", 1865.**

It's difficult to make comparisons with the past because technology, just like the world as a whole, changes all the time. But just as in the early days of what we now call the Internet, the metaverse is not seen entirely as a positive development.

Some investors may dismiss all or some of this negativity but it would be short-sighted not to recognise that many concerns around the metaverse stem from the operational weaknesses of the Internet and social media. Others are actually related the ambiguity of the concept itself, often leading to narrow interpretations of what it can or cannot do.

We do acknowledge fundamental sustainability problems with cryptocurrencies[15] (and public blockchain platforms), which are supposed to be the money of the meta world, and how crypto "assets" plummeted over the past year amid allegations of fraud and money laundering.

We understand legitimate concerns about social media platforms being the first to jump on the metaverse bandwagon whilst being scrutinised for data privacy and antitrust practices.

Clearly, there are important questions that will need to be addressed with all the seriousness that they deserve.

Looking from the purely technological perspective, we are convinced that by further harnessing computing power that has piloted us into Information Age in the first place, the metaverse could become a more immersive and organic extension of the Internet, with tailor-made opportunities not only in entertainment, but increasingly in other domains such as education and manufacturing.

And that is an important pre-requisite for creating a whole range of attractive opportunities, subject to technology being used in in the right way, fully aligned with global sustainability objectives. Such opportunities may include several themes, such as:

1. Optimisation of manufacturing processes, maximising productivity gains whilst reducing carbon footprint

2. Homeworking, increasing immersivity of new, decentralised, ways of working

3. Increasing the interactivity of education and professional training, bringing them to larger audiences

The Internet has evolved greatly over decades, whether in terms of performance, security or its ability to change the way we use IT, such as Software as a Service (SaaS)[16]. More fundamentally though, it is about how the cyber space has become more intertwined with our daily life. Similarly, we believe that over the next few decades the evolution of the metaverse will take it in many unforeseen directions, as it adapts to changing times, and changing people's lives in the process. It is up to investors and regulators to make sure that these changes are all positive.

Notes & References.

1 https://www.merriam-webster.com/words-at-play/meta-adjective-self-referential

2 https://www.techtarget.com/whatis/definition/Web-30

3 https://news.cnrs.fr/articles/a-digital-twin-for-notre-dame

4 Haptics - the use of technology that stimulates the senses of touch and motion, especially to reproduce in remote operation or computer simulation the sensations that would be felt by a user interacting directly with physical objects.

5 https://www.technologyreview.com/2022/12/05/1063828/the-industrial-metaverse-a-game-changer-for-operational-technology/#:~:text=The%20industrial%20metaverse%20could%20also,with%20Taqtile%20is%20one%20example.

6 Bloomberg Intelligence, https://www.bloomberg.com/professional/blog/metaverse-may-be-800-billion-market-next-tech-platform/

7 https://new.siemens.com/global/en/company/insights/siemens-and-nvidia-partner-to-build-the-industrial-metaverse.html

8 https://www.statista.com/statistics/881541/bitcoin-energy-consumption-transaction-comparison-visa/, as at 25 April 2022

9 https://venturebeat.com/virtual/how-the-metaverse-could-bring-us-closer-to-a-sustainable-reality/

10 See Candriam's white paper on cryptocurrencies, p 17 for Proof-of-Work and p 22 for a comparison to Proof-of-Work. https://www.candriam.com/en/professional/insight-overview/publications/research-papers/cryptocurrencies-and-esg-a-contradiction-in-terms/

11 The Merge brings down Ethereum's network power consumption by over 99.9% (cointelegraph.com)

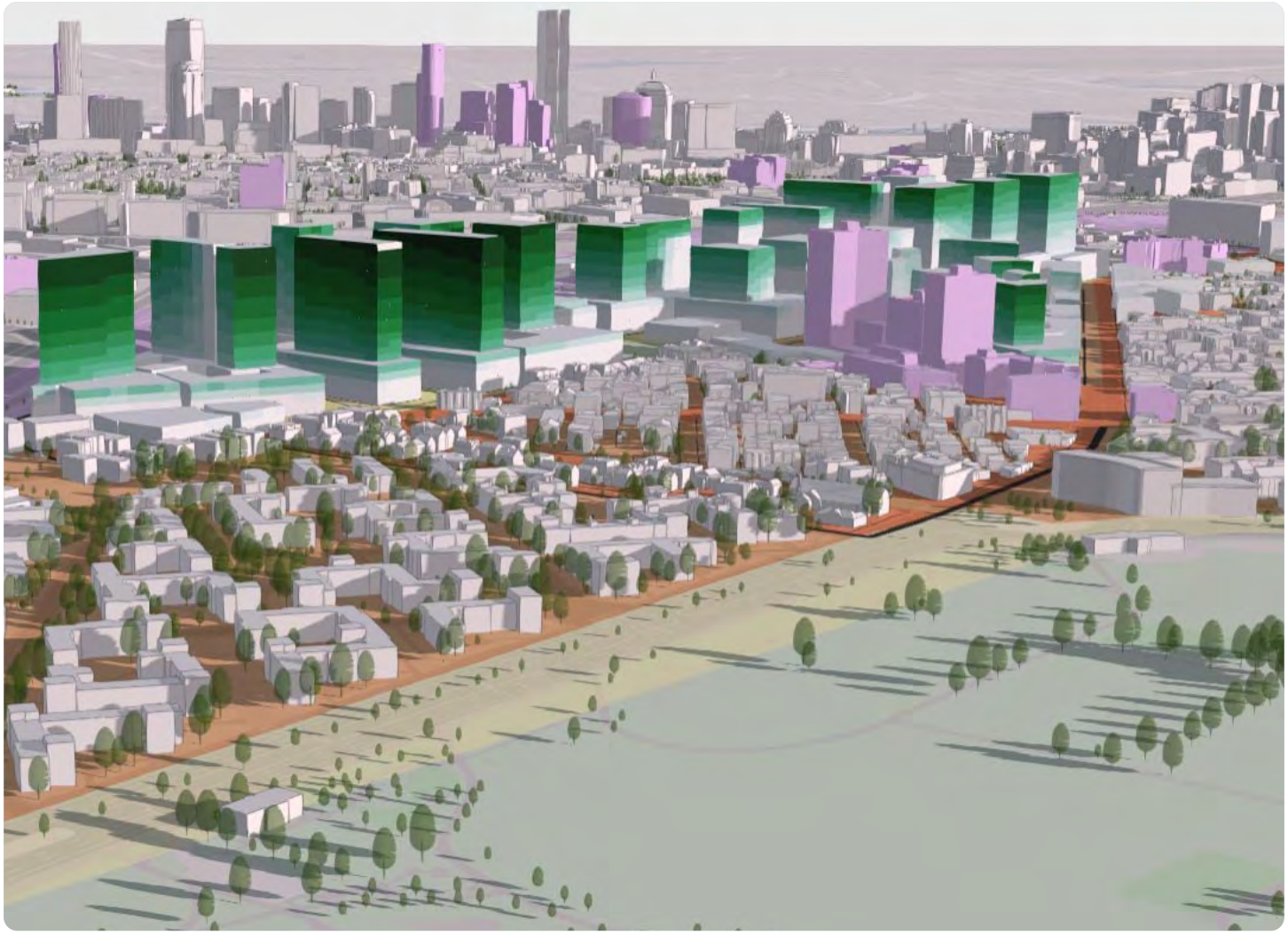
12 https://www.statista.com/statistics/1265891/ethereum-energy-consumption-transaction-comparison-visa/

13 From p 79, p 677 – 693, onwards https://www.intelligence.senate.gov/sites/default/files/documents/report_volume5.pdf

14 An on-premise setup requires in-house server hardware, software licenses, integration capabilities, and IT employees on hand to support and manage potential issues that may arise. This doesn't even factor in the amount of maintenance that a company is responsible for when something breaks down or doesn't work.

15 Please see Candriam's white paper on cryptocurrencies. https://www.candriam.com/en-kr/professional/SysSiteAssets/medias/publications/brochure/research-papers/cryptocurrencies/cryptocurrencies_2021_en.pdf

16 Software as a service (or SaaS) is a way of delivering applications over the Internet—as a service.



Visibility analysis in Boston, United States, using ArcGIS Urban. Powered by Esri.

€139 B

AUM at end December 2022*

600

Experienced and committed professionals

+ 25 years

Leading the way in sustainable investing

*As of 31/12/2022, Candriam changed the Assets Under Management (AUM) calculation methodology, and AUM now includes certain assets, such as non-discretionary AUM, external fund selection, overlay services, including ESG screening services, [advisory consulting] services, white labeling services, and model portfolio delivery services that do not qualify as Regulatory Assets Under Management, as defined in the SEC's Form ADV. AUM is reported in USD. AUM not denominated in USD is converted at the spot rate as of 31/12/2022.

CANDRIAM. INVESTING FOR TOMORROW.

WWW.CANDRIAM.COM

CANDRIAM

A NEW YORK LIFE INVESTMENTS COMPANY