WS AMATI GLOBAL INNOVATION FUND

Innovation Frontier

Digital Twins

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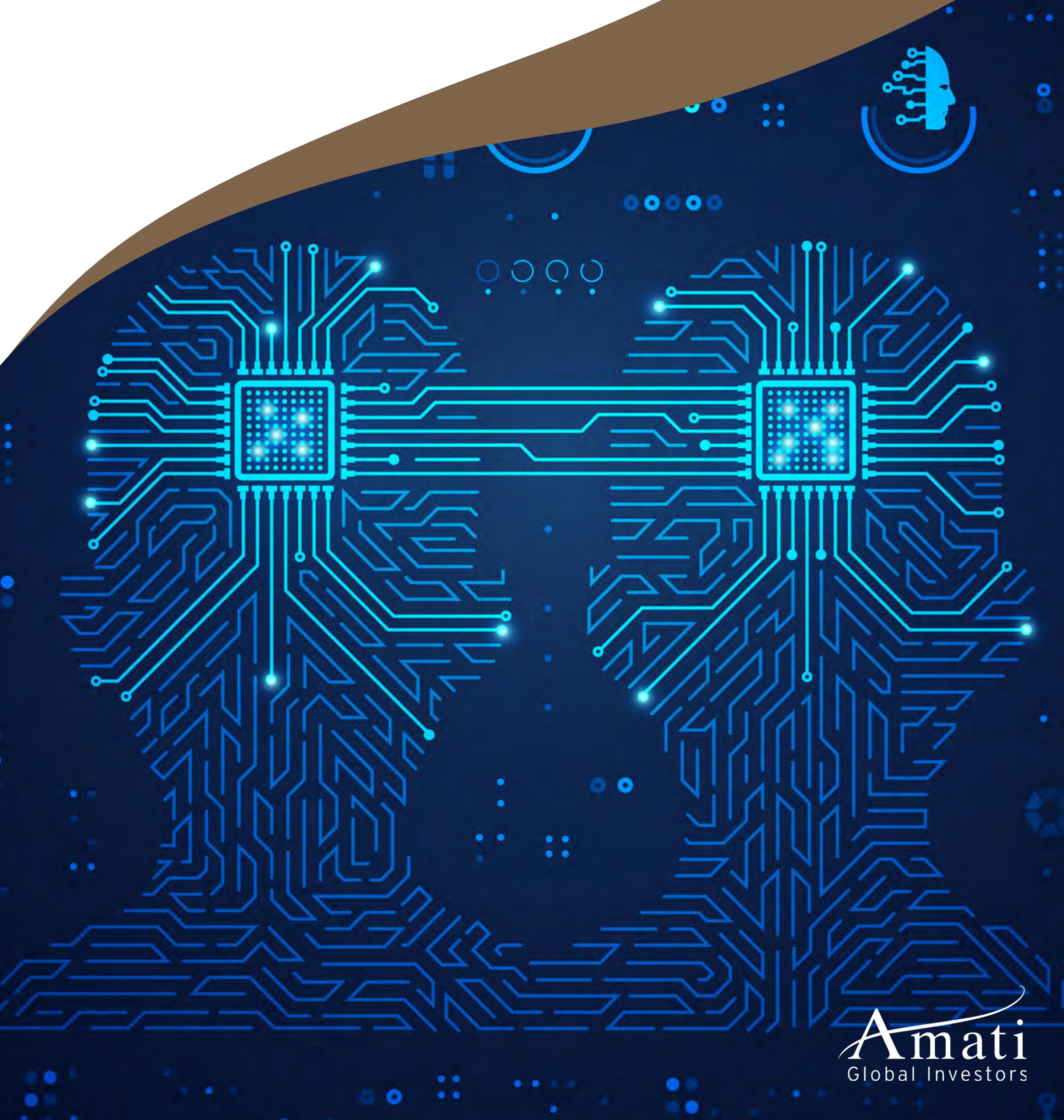

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“Cyberspace. A consensual hallucination experienced daily by billions of legitimate operators, in every nation, by children being taught mathematical concepts... A graphic representation of data abstracted from banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the nonspace of the mind, clusters and constellations of data. Like city lights, receding...”
— William Gibson, Neuromancer, 1984

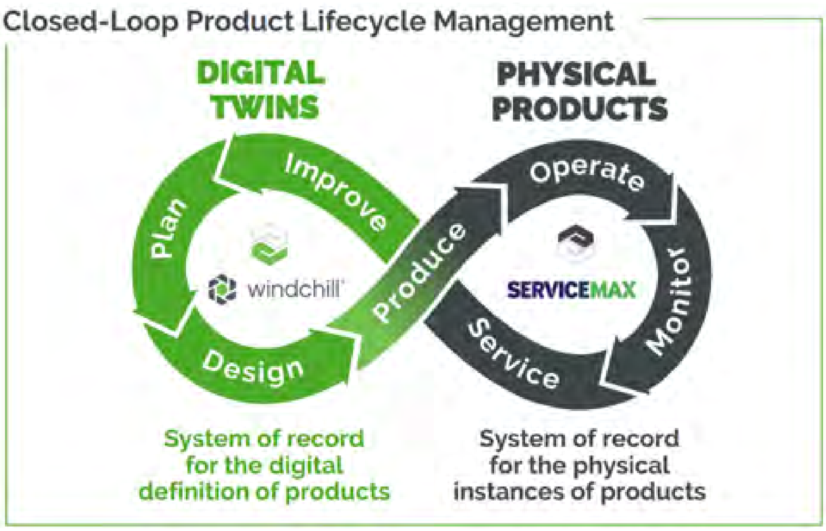
Although I have never had the pleasure, I am told that players of 'Watch Dogs 2' and 'The Division 2' are treated to an uncannily accurate depiction of San Francisco and Washington DC respectively. The games' designer (Ubisoft) prides itself on creating accurate city replicas, even down to a full recreation of Paris at the time of the French Revolution for their Assassin's Creed franchise. In fact, so accurate is their depiction of Notre Dame in the game that the company collaborated with historians after the building was partially destroyed by fire in 2019. The digital files became a reference for the reconstruction of the Cathedral. Without expressly intending to had Ubisoft accidentally created a digital twin? The answer is sort of, but not really.

Source: Ubisoft

The Notre Dame example highlights a key element of a true digital twin - connection. While Ubisoft had created a very accurate digital replica there was no on-going connection with the physical asset which is a vital aspect of twinning. If the crypt had been renovated or the pulpit relocated, the digital version would not reflect this and so lose its significance. For a digital twin to be valid there must be a continuous (or at least frequent) data exchange between the physical and digital versions. The simulation must accurately reflect not only the physical asset but also its behaviour and function.

The true benefits of digital twins come from the stream of operating information that allows technicians to monitor the condition and efficiency of the asset. One of the best early examples comes from Rolls Royce, the aviation engine manufacturer. For more than 30 years Rolls Royce has been a leader in Engine Health Monitoring (EHM), which today is a fully live and continuous stream of measurements from its installed base of aircraft engines during flight. Rolls has gradually increased the number of sensors and frequency of contact for each engine to the point where they now collect more than 70 trillion data points every year. This information helps them to anticipate any required maintenance, maximising the flying time and minimising the costs of servicing. Importantly, the point is not simply to repair problems before they escalate, but to avoid replacing parts that may still have a serviceable life. Each engine now has a complete digital twin that can also be 'stress tested' under hypothetical conditions to assess performance and fatigue. Far less risky to do destructive testing on a simulation than in the real world.

A more recent, but similar example is Tesla who operate digital twins of all of their vehicles. Again this allows them to track issues and maintenance schedules, but can also use the data to improve future designs. Companies like **PTC**, the design software specialist, are increasingly integrating digital twin technology into their so called 'digital thread'. This is the concept of the journey a new product takes through computer design, optimised manufacturing and then lifecycle maintenance. The additional detail provided by the digital twin feeds back into this cycle to constantly improve the journey and optimise the digital thread.



Source: PTC Investor Presentation

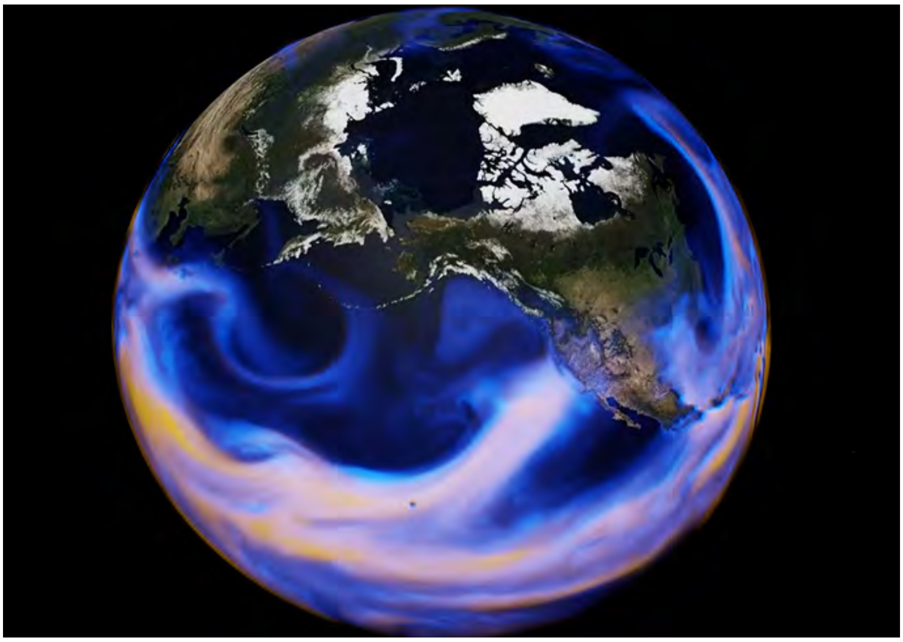
While the primary use for digital twins tends to be focused on cost saving and efficiency of the related asset, it can also lead to savings elsewhere. Take the digital twin of a chemical plant or a manufacturing facility for example. Initial staff training can be carried out in an entirely safe environment by introducing new recruits to the facilities and their tasks using the digital twin and a virtual reality headset. In Shanghai the Urban Operations and Management Centre has created a digital twin of the city which includes thousands of individual elements and allows the simulation and control of amenities across the city including traffic management, e-bike charging, and even refuse collection. The model is kept up to date using a combination of static sensors, satellite imagery and even regular drone inspections.

The range of applications is almost unlimited and this is reflected in the view of Allied Market Research that **the global digital manufacturing market will exceed $1.3 trillion in 2030, up from $275 billion in 2020.**

Why now?

Clearly the concept of the digital twin is not new, and even the term is widely thought to have been coined more than 20 years ago, so why focus on it now? As we frequently mention, individual innovations often only truly come of age when they coincide with adjacent technologies that clear the path for broad adoption. In this case it is a combination of the widespread and growing adoption of cloud infrastructure and the advancements in processing power, particularly from Graphic Processor Units (GPUs). The shift of organisations onto cloud infrastructure provides a highly flexible but very secure platform from which to manage data. It also allows for seamless connection to connected devices or sensors which provide the flow of data from the physical asset. To manipulate and interact with complex simulations, as well as testing them under different hypothetical scenarios, requires heavy-duty processing of the kind we have become familiar with for gaming and increasingly Artificial Intelligence (AI).

Consider the highly ambitious plan by **NVIDIA** to create a virtual twin of the Earth in order to model weather patterns and climate changes. The system combines NVIDIA's 'Omniverse' 3D simulation platform and their 'Modulus' AI physics engine and is being used by wind farm operators such as Siemens Gamesa to optimise turbine location and assess the impact of weather on likely output. While a very extreme example it brings home the level of capability now present in terms of available processing power. Unthinkable just a few years ago, the system enables prediction of weather events up to 45,000x faster than traditional models.



Source: NVIDIA

From a connectivity standpoint the development of low cost and low energy radio frequency (RF) devices has been crucial for the roll out of sensors in sufficient scale to meet the data requirements for the industrial Internet of Things (IoT). The addition of sensors throughout industrial plants and machinery, for example, provides the real-time feedback that makes digital twins so effective. In addition to traditional heat and vibration sensors companies are creating novel solutions using machine vision to monitor movement or deformation. Cordel, a company held in the Amati AIM VCT fund, uses LIDAR sensors on trains to map and monitor a digital twin of the railway network. Gathered data is then transmitted using standards such as Bluetooth low energy (BLE), WiFi6, 5G cellular and LoRaWan. This variety of technologies has been established to suit different applications depending on energy availability, required bandwidth and distance of transmission. Without the availability of low cost devices using these protocols the dream of digital twins could not be realised. Our holding in Nordic Semiconductor is a key beneficiary of this trend for BLE applications in particular.

Breadth of Applications

As we have seen, the potential of digital twin technology is vast, and it plays a role in a number of the investments in the fund. In addition to PTC and NVIDIA mentioned above, **Jacobs Solutions**, a technical consulting firm listed in the US, specialises in helping clients to create digital twins of a wide range of products and assets. Working directly with Bentley Systems [1] they assisted the Singapore National Water Agency to develop and trial a whole plant simulation model for the Changi Water Reclamation Plant (CWRP).

Source: Jacob Solutions

Accenture recently invested in Virtonomy, an early stage digital twin software company focused on the medical sector. Virtonomy's product uses the growing pool of patient data to create accurate anatomical simulations allowing device manufacturers to test new products in a safe virtual space. The systems is said to reflect variations in factors such demographics, anatomy and pathology. This is but one example of numerous initiatives to embrace digital twins within the life sciences sector. Other projects include creating a digital replication of a human brain, as well as ultimately replicating the entire body on the road to personalised medicine and virtual reality based surgical training.

Reply is an Italian listed technology consulting and services company held in the portfolio that incorporates several business areas focused on Internet of Things (IoT). They have worked with numerous clients to build twins of factories and industrial plants for operational optimisation and monitoring. However, by utilising the developing augmented and virtual reality applications such as Microsoft Mesh or realworld one they can take the functionality to the next level and collaborate and interact with the simulated asset in a meta-environment.

GEA, a German process equipment company held in the fund uses this approach today to provide remote training and technical assistance for their products.

Source: GEA Website

The Future

As digital twins proliferate across industrial and life science applications the complexity and interaction will continue to increase. Products, processes, supply channels and then lifecycles will be mapped and monitored and the boundaries between individual assets will become increasingly blurred until entire industrial ecosystems are twinned with their digital counterparts. More and more control will be exerted remotely through the digital medium - the enterprise metaverse. In consumer applications the ‘metaverse’ has created much hype but little substance so far, but this contrasts sharply with the situation across industry. The opportunity for remote collaboration and training has attracted significant investment and innovation and is increasingly becoming commonplace. Companies which embrace this transition early are likely to drive efficiency and profitability ahead of their slower moving peers, particularly when combined with the burgeoning power of machine learning technologies and the extension to artificial intelligence. A digital environment will allow for more direct interaction with AI taking people away from the mundane elements of control and monitoring. Whether or not you like the look of this developing reality, it is largely already here but just 'not yet evenly distributed'[2].

[1] - Not a holding in the fund

[2] - From a quote by William Gibson, Pattern Recognition, 2003

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