RESPONSIVE SYSTEMS: Digital Twins

Big events like world wars or global recessions accelerate learning and cultural change. The pandemic we are currently dealing with is no exception. Changes to how our buildings and infrastructure function have been spectacular in the short term and look set to remain in flux for some time to come. One day, with digital twin technology our buildings will respond and adapt to this uncertainty dynamically and help us plan for change more effectively.

Here Board Director, Richard McCarthy discusses the digital twin and why now could be the tipping point in its evolution.

IS NOW THE RIGHT TIME TO INVEST IN CREATING A DIGITAL TWIN OF YOUR BUILDING?

So what is a digital twin and why could now be a tipping point in its evolution? Well, digital twin technology offers the opportunity to plan and predict how we use our buildings with an intelligent replica. It is a 'live' responsive system connected in real time between the physical and digital systems.

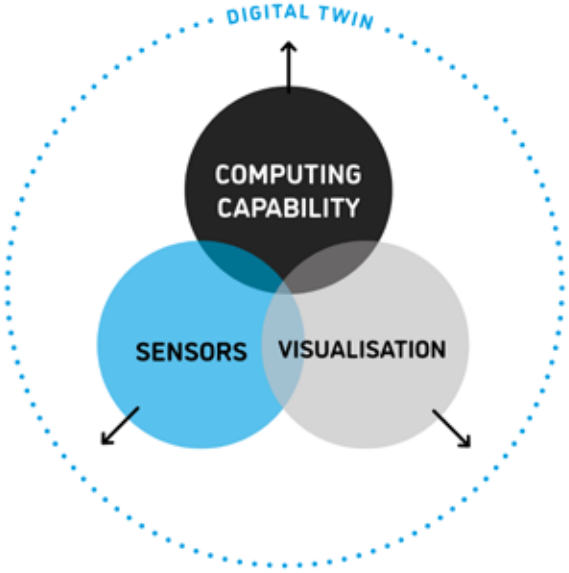
The idea has been around for a long time. In the 1980s titans of industry like, Rolls Royce and Siemens worked with simulations called 'digital shadows'. Even earlier, in the 1960s, NASA used 'pairing technology' to help launch Apollo 13.

The term digital twin was first coined in 2003 by Dr Michael Grieves as part of his work on whole life costs. He said recently: "*The digital twin, concept from its origin over a decade ago to today, has always relied on progress in two very different areas: technology and culture*".

Great ideas often arrive before we have the know-how to really make them zing. And often before we know why we need

ABOVE
Digital Twins are likely be much more widely-used in the near future

BELOW
Diagram showing three major advancements in technology that have enabled Digital Twins in Manufacturing. *Source: Dr Michael Grieves article - Perspective, ARUP Digital Twin Report, Novemer 2019*



them. As Henry Ford famously said, '*If I'd asked people what they wanted they'd have said "a faster horse"* '.

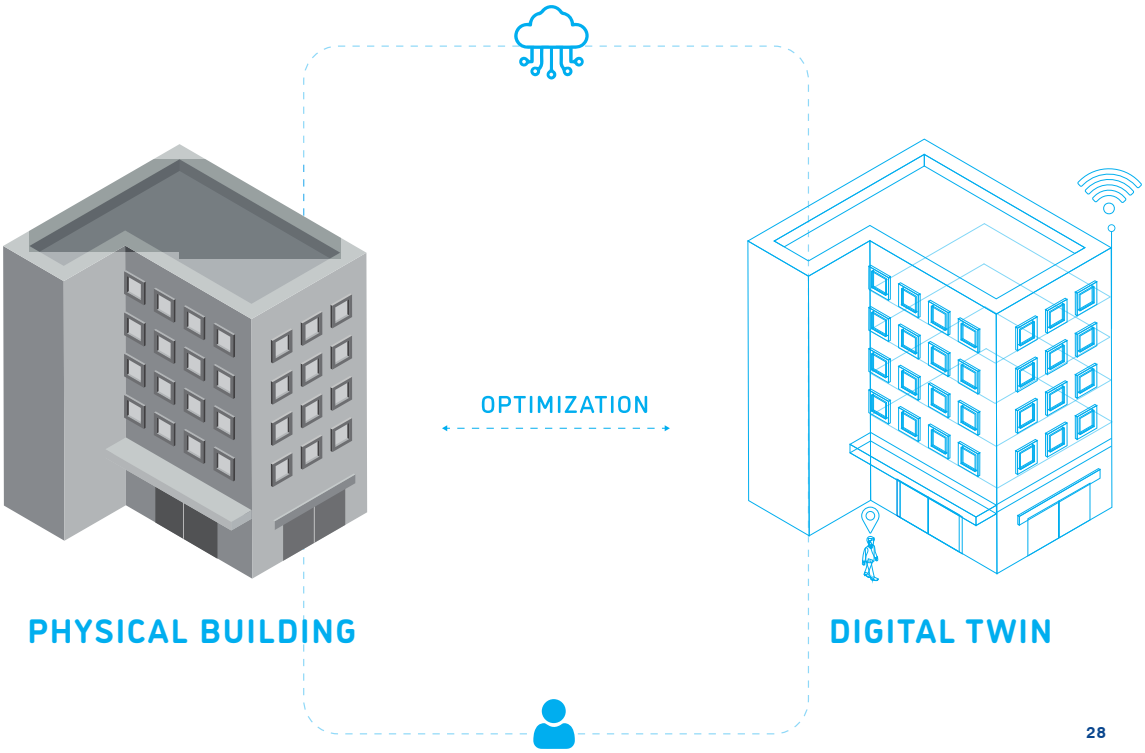
In the last decade computing power has more than doubled every eighteen months (Moore's Law). All this processing power means the idea that machines can learn and adapt through experience is now a reality. We've reached a point where when you combine machine learning and AI with the Internet of Things (IoT) sensors that gather data in the real world. The digital twin concept is now viable on a scale that starts to makes sense, for the built environment to engage with.

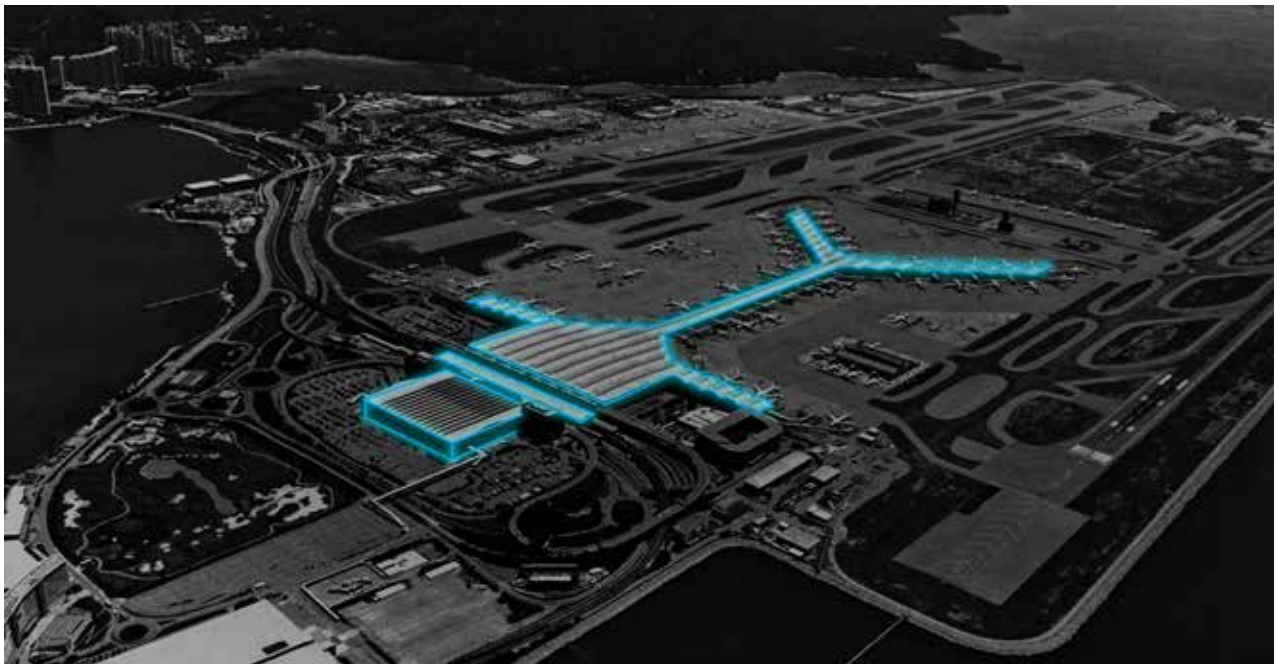
Culturally however these technologies are highly disruptive and people, especially property people are hesitant to adopt new ways. They need to be brought along or shocked in to action. Nothing brings people along faster than a global crisis where the value of being able to plan and test response scenarios in real-time with everything you need at your fingertips becomes readily apparent. Cue Covid-19.

TYPES OF DIGITAL TWIN

Back in 2000 we began talking about smart cities. It started to become a reality when Google Maps was launched in 2005. A form of digital twin we all rely on to navigate and find what we need close by when we need it. In 2010 Google announced its self driving car development. A baton picked up by Uber's self driving car division, the Advanced Technologies Group. Integrating automated vehicles is a key challenge for our cities on their smart journey. Singapore has created a digital twin of the entire city they are using to plan for the arrival of automated vehicles.

BELOW
How it works: A Digital Twin is a virtual 3D model which integrates data from different sources. It is made available real time and can be visualised and analysed through a human-centric interface to make predictions.





This type of digital twin brings together network of systems at a city scale but the fidelity of the model as with Google Maps is still fairly basic. At a smaller scale components parts such as engines or assets like an airplane, or F1 car are developed and tested using high fidelity digital simulations.

Rolls Royce recently announced plans to expand its digital eco-system beyond design simulations and create digital twins of all its physical products in-field to obtain and exchange real time data and controls with its customers, partners and suppliers. It's not dissimilar to how apps on your mobile devices continually feed data back to Apple or Google and their developer partners to improve the user experience.

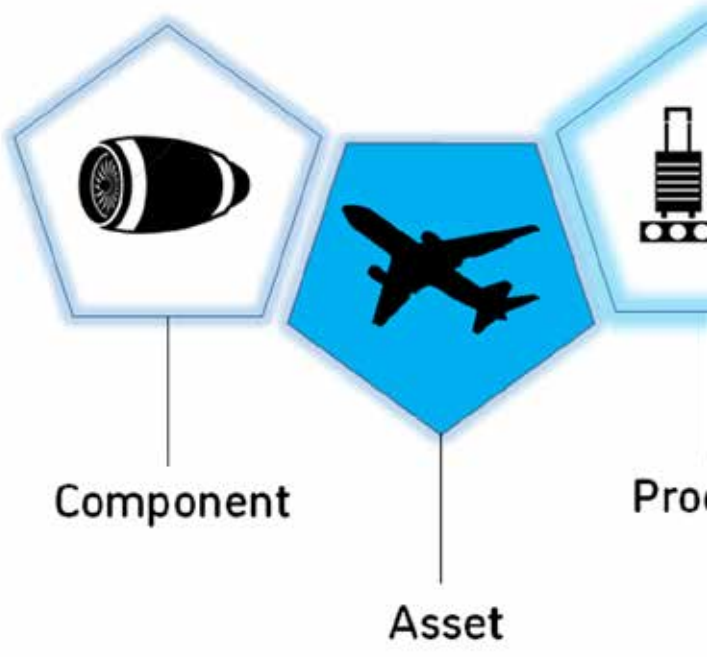
In between the city scale and component scale of digital twin technology, sits our buildings and infrastructure. They require a relatively high level of fidelity but also contain a significant number of decentralised systems. Each generating data streams that have to be mapped to the digital twin and made sense of. This takes a lot of computing power and complex modelling which perhaps explains why digital twins at building scale have lagged behind their industrial counterparts.

BUILDING OWNERS WILL IMPLEMENT DIGITAL TWINS SIMPLY AT FIRST

A digital replica of your building in itself is a useful commodity. It replaces rooms full of dusty old drawings, manuals and specifications. Both digital and paper information with a dimensionally accurate, as-built model of your building covering every nook and cranny. A single source of truth.

This is a great base to plan and react to situations like a pandemic with confidence but a digital twin is so much more than just a replica of your building. A digital twin gives you a comprehensive snapshot of all functioning parts of your built environment in real time. It tells you how they are interacting with the people using your building.

Imagine a child accidentally drops a coin into the mechanism of an escalator. An oscillation sensor linked to the digital twin is listening and detects a slight change in frequency. A maintenance crew is dispatched to retrieve the



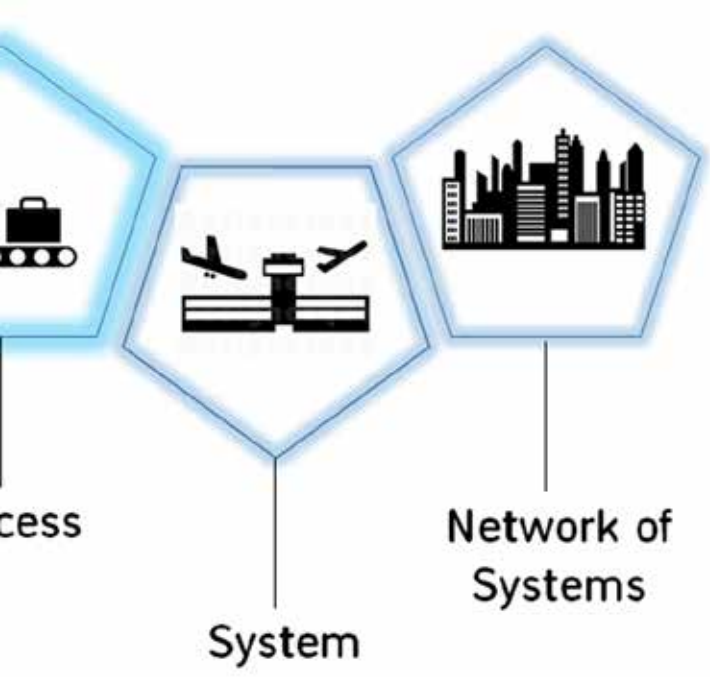
LEFT
Hong Kong Airport currently utilises a Digital Twin

BELOW
Hong Kong Airport Departure Lounge and types of Digital Twins

coin immediately, before it causes more serious damage and puts the escalator out of action for weeks. Oscillation sensors have been used as a preventative measure on oil rigs for years but now they're part of your buildings arsenal of digital tools.

How often this happens, how long it takes for the maintenance crew to reach the escalator and deal with the incident, the impact on movement and waiting times due to an escalator being down temporarily, is all information stored by the digital twin. Overtime the model evolves using this type of behavioural and operation data to learn and provide insight at each stage of the assets life-cycle. This includes dealing with a crisis. Valuable data on how systems interact with people, the weather and other variables will improve the accuracy of predictive modelling.

Although the benefits of a digital twin are easier to see and measure in the controlled environment of product development and industrial processes, building owners are starting to take the leap and invest in digital twins.



It's because of not despite their complexity that building types such as airports and hospitals with big operational expenditure budgets are latching onto the cost saving benefits of developing digital twins to help run their facilities. They will start simply but overtime the digital twin will evolve to collect and visualise the right data, apply the right analytics and rules.

Hong Kong International Airport is a good example. Their vision is to develop itself into a smart airport, using digital twin technology to create an enjoyable and hassle-free experience for passengers. Imagine arriving at the airport, your pre-approved avatar appears in the digital twin and you glide seamlessly to your seat on the plane. Subtly tempted by advertisements of all your favourite products along the way.

In the meantime whilst they develop the technology to realise this vision, Hong Kong believe the digital twin will deliver immediate operational and capex planning benefits.

In a Covid-19 scenario the digital twin of your airport can be used to run simulations testing the impact on queuing times for different screening configurations. Using back data to help inform capacity studies and analyse the impact of social distancing measures have on people flow.

MANAGING OUR RELATIONSHIP WITH BIG DATA

How we visualise data is important. In his 1984 novel Neuromancer, William Gibson invented cyberspace, a virtual reality data-space called the 'matrix'. Giant corporations represented by imposing architectural constructs of data you interact with like a physical building. A 3D model of your building provides a familiar setting to interact with its digital systems in much the same way as the desktop environment on your computer replicates an old fashioned office setting with its filing cabinets and waste paper bin.

People are understandably reticent about how data about them, captured by digital twins in the built environment is used. One of the worlds most ambitious smart city projects planned by SideWalk Labs, in Toronto was canned this year. Although this decision was financially driven. It previously faced pushback from Canadian leaders, concerned about safeguards to protect residents and visitors from the kinds of ubiquitous and intensive sensor-laden infrastructure that was envisaged.

During the Covid-19 pandemic, implementation of big brother style 'track and trace' technology may have blasted away some of these fears. People have been forced to compromise on privacy for the benefit of health and well-being.

Up until now digital twins have largely been the domain of industry and manufacturing, whose facilities and processes have limited interaction with people. The technology is coming of age, but are we ready to start seeing digital twins play a bigger part in controlling the buildings and spaces we actually inhabit? ●