TWIN CITIES

VEDA BALIGA EXPLAINS HOW VIRTUAL REPLICAS OF BUILDINGS AND EVEN CITIES CAN BE USED TO TEST THEIR BEHAVIOUR AND FUTURE-PROOF THEM

Urban planners and designers have long used 3D models to design and develop spaces. However, what is often lacking is the ability to easily incorporate and visualise the environmental impact of design decisions. With the climate emergency looming, there is a need to address this as quickly as possible.

We're in the middle of the Fourth Industrial Revolution and while digital technology delights us, it is also set to disrupt business as usual. Digital Twins are virtual replicas of any physical asset, that can be used to run simulations before construction, optimise deployment for peak efficiency, and look at what-if scenarios. In the built environment, they will change how we think about the interconnections between technologies such as GIS, building information modelling (BIM), performance analysis, the Internet of Things (IoT), artificial intelligence (AI), machine learning (ML) and Big Data analytics.

A Digital Twin should replicate not only the form and function, but also the behaviour of its real-life counterpart. In the built environment, this means that it must incorporate consideration of building physics, alongside its use of data, AI and ML techniques.

While AI and ML learn from historic trends found in data, physics-based simulations model and predict behaviour based on the laws of physics. Therefore, it is vitally important that the model knows where and when that data is from, and where in the world the buildings or development are.

It is almost as important to know this geospatial context as it is to know what the proposed design, materials or layout is. The weather and relative position and orientation of the building to the sun will have a big impact on performance and the energy required to keep internal conditions comfortable and healthy.

A new workflow

CAD and GIS technology emerged in the 1980s and 90s as a replacement for paper and pen for professionals who needed to work with spatial information. However, the complexity of software and capacity of hardware during that time limited the possibility of what could be done with technology for drafting and for spatial analysis. Therefore, CAD and GIS appeared to be competing computerised tools for working with geometry and data to produce documentation. However, the development of BIM alongside CAD and similar developments in GIS means very few see these technologies as competing.

The same is true with emerging Digital Twin technology. It would not be possible without the increasing availability of sensors, image capture and analysis technology, as well as powerful data transfer and cloud-based processing capabilities. And while it may be difficult to reconcile GIS and Digital Twins today, the technology is developing rapidly and their relationship will soon become clearer.

For example, the idea behind a utility GIS is to create a virtual, visual, geospatial representation of an infrastructure network. So how does this differ from a Digital Twin? Although a GIS may consist of accurate locations and attributes of the network, it is still merely a representation and doesn't capture the behaviour of the network. If there is no IoT connection, the data used in the GIS is very often out of date moments after it is captured, meaning that it is not a true reflection of reality.

Digital Twins enable engineers to gain a better insight into the operational

performance of the asset in real-time. As a result, utility asset managers are unable to make definitive assessments and informed decisions without first consulting site-based inspectors and collating large amounts of measured or calculated data.

BIM is similar to GIS in the sense that unlike a Digital Twin, a BIM model very much remains a static representation or 'snapshot in time' of the building, based largely on design assumptions or construction documents. BIM provides a central point of reference throughout the lifecycle of a construction project. It is an important data repository that enables the visualisation and management of building data and facilitates collaboration across the whole project team.

The same is true for both GIS and BIM models – they do not include the dynamics of a live Digital Twin, which can behave exactly how its real-life counterpart would behave, enabling 'experiments' to be run on the twin to assess the impact of changes on performance, understand any knock-on effects that might not be immediately apparent and deliver the information needed to make informed decisions that improve performance. However, that does not mean that GIS and BIM are obsolete – they do not compete and can and should be used in combination.

Redefining concepts

To understand how information can be used across BIM, GIS and Digital Twins, we need to redefine our concepts of buildings, communities and cities, and understand how different disciplines need to use a wide range of project data in a geospatial context. Geospatial information augments the world of IoT and helps the Digital Twin to become aware of both the actual and relative position of its real-world counterpart – where the asset was/is in relation to its surroundings and the environmental conditions in which it lives. Data, such as boundaries, land parcels, built surroundings and environmental information, helps to provide a digital context into which an asset's Digital Twin can be created.

However, integrating all these technologies is a lot more complicated than simply viewing graphics and properties from a 3D model and displaying them. To realise the full potential of integrated workflows between BIM, GIS and Digital Twins, we need to look closely at how they can move forward toward complete digitised workflows that will allow us to move away from the paper processes of the past. We have come a long way already, but technology is developing at an ever-increasing rate – faster than the way people work, and a 'slow to adapt' culture, a lack of interoperability and competing data standards are preventing truly integrated workflows.

We're already starting to look at how we can fix this. Here at IES, our own Digital Twin technology – the Intelligent Communities Lifecycle (ICL) – is making it possible to bridge the gap between the real world and simulation to enable the energy-efficient design and continuous operational optimisation of not just single but entire groups of buildings. The ICL ecosystem leverages open source datasets such as OpenStreetMap and terrain data from US and EU organisations to provide the geospatial context within which Digital Twins for existing or new developments can be created and evaluated. This ensures that all models are geolocated, and provides a common geographical and physical context for various disciplines during the design, construction and operation lifecycle.

A more resilient and efficient future

A Digital Twin that focuses on the operational performance of the built environment can deliver energy resilience, cost savings and resource-efficiency for buildings, campuses, communities and cities. The ability to analyse the behaviour of an asset in any geographic location at any scale – from the entire Earth to a continent, country, city, community, building or a single room in that building – means there is the potential to look at the bigger picture and make small but meaningful changes that will have cascading impacts.

A DIGITAL TWIN CAN BEHAVE EXACTLY HOW ITS REAL-LIFE COUNTERPART WOULD BEHAVE, ENABLING 'EXPERIMENTS' TO BE RUN ON IT

The power is in the insights they can provide through simulation, analysis and data visualisation, all in one platform; helping a wide range of disciplines collaborate and understand complex information to make fact-based decisions. They can be used to answer questions concerning community-wide solutions, such as 'How and where can we make the best use of geographically distributed small-scale renewables?' and 'What savings could be achieved through installation of a district heating system?'

Resilience, not just in our utility networks, but also in our buildings and their ability to deal with changes to the climate, is a huge issue. Warming the planet more than 1.5°C is a real threat to liveability, and this could happen as soon as 2030. Reducing carbon emissions

to the level that we need in the short time that we have is an enormous challenge.

When planning our developments, communities and cities, our biggest consideration should be 'how do we keep carbon emissions as low as possible?' However, we must also simultaneously look at how we mitigate climate change. This is where resilience and future-proofing comes into play.

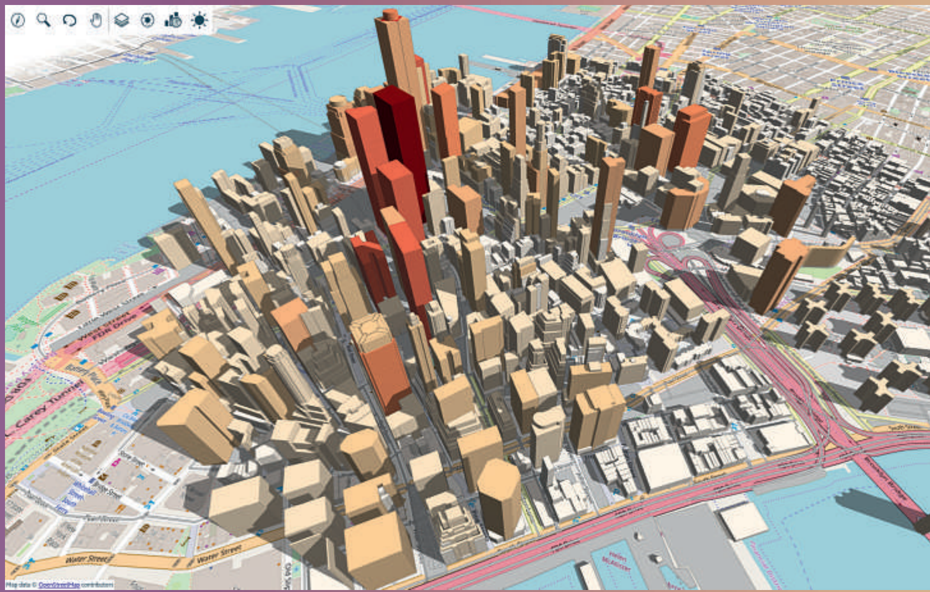
Using Digital Twin technology, we can test how our developments will behave and perform over time under more extreme weather conditions and how resilient they will be. We can evaluate the impact of our decisions now, to see whether they actually help make things better in the long term or worse.

Conclusion

As with any emerging technology, it will take time for the industry to fully understand and embrace the opportunities that Digital Twins can offer. Given that the technology is not mandated, it will be incumbent on individuals to recognise the added value a Digital Twin presents at all stages of the building lifecycle and pave the way for more widespread implementation.

Digital Twins that integrate with other platforms, as well as use advanced data analysis, AI and ML techniques, have the potential to make a profound difference to the future of our planet, whilst enabling everyone working on planning, designing and creating communities and cities to work more efficiently and collaboratively towards the same goal.

Veda Baliga is senior product manager at IES (www.iesve.com)


City information model of New York displaying the shadows for daylight and shading analysis

A screenshot from the interactive touch screen model of the Nottingham Trent Basin community


Graphical representation of a Digital Twin of San Francisco