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A Bird's Eye View: How the World's First Digital Twin of a Nation Can Help Create Better Cities

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Aircraft armed with laser scanners patrolling the skies to create a digital copy of one of the most densely populated islands in the world? Twenty years ago, this would have sounded like science fiction. However, this is exactly what happened when the Singapore Land Authority (SLA) went about making the world's first digital twin of a country.

Singapore has needed to become used to flash flooding. However, torrential rain caused a series of nine damaging floods throughout 2011, causing the nation to look at ways to tackle the problem.

Alongside that challenge, as a small island and the world's most densely populated nation with a population above 1 million inhabitants, Singapore's land use needs to be carefully considered.

To help make better use of Singapore's scarcity of land and to figure out the areas that are most at risk from flooding, SLA began to create a 3D map of the country starting in 2012.

GPS Lands Singapore later approached SLA with a plan to develop Virtual Singapore, a digital twin using software provided by Bentley Systems. It was then that the laser-scanning aircraft came into play, the mapping team using it to record terrain and surface information to a minute level of detail. Lasers mounted on vehicles also roamed Singapore's streets, absorbing data to supplement the aerial imagery with street-level information.

GPS Lands Singapore then combined all these data sets into a single platform, allowing users to view and verify information to help inform and improve urban planning and design.

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Completed earlier this year, Virtual Singapore is recognised as the first digital twin of a country.

The digital twin displays all of Singapore in a highly detailed 3D representation that has been exported and shared across various government agencies to help with asset management and decision-making, including detailed tree and green space management.

Belowground, the SLA is now working on the next stage of the project, a national subsurface digital twin of Singapore.

Almost all the city state's utility assets are buried underground to free up valuable aboveground space for other purposes. However, Singapore's ongoing expansion—both aboveground and belowground—means that even the subterranean space is becoming increasingly scarce.

Not only does this level of complexity increase the challenges and costs faced by government agencies and utility companies every time they need to do a new project, but it also significantly increases the risk of damaging an underground asset during construction or excavation work.

Capturing and maintaining reliable information about underground utilities has several benefits. Land aboveground and belowground can be managed better and used more efficiently. There are also fewer risks around the planning and delivery of infrastructure, and the clarity means that there is minimal disruption to services and increased safety during engineering works.

Aside from some of the more practical uses around the management of Singapore's land, the evolving digital twin can help overcome other challenges as the nation continues to grow and expand.

Working with phone and internet providers, the map can help examine the coverage of phone networks, providing realistic visualisation of areas suffering from poor coverage to help inform and influence the best locations for phone masts and power lines.

Incorporating real-time data, the map can also assist emergency services with disaster planning and enable them to simulate evacuation scenarios and the impact of crowd dispersion.

For less dramatic scenarios, the map can also be used to analyse transport flows and pedestrian movements to prevent bottlenecks and ensure a more efficient flow of movement around the city.

Virtual Singapore has two aspects that make it so significant and influential. First, the level of technological ingenuity and detail enables it to be such an accurate and evolving resource. Second, and perhaps most importantly for its long-term use, the map is open and collaborative.

Accessible to the public, as well as private, government, and research sectors, Virtual Singapore has the potential to stimulate a wave of innovation and integration in the design and development of smart cities. By capturing a raft of data, Virtual Singapore can also ensure construction and infrastructure lessons are learned and shared before they pose extensive, and often expensive, urban planning problems enabling planners to design and build a better country.

The Singapore project might be one of the most dramatic implementations of digital twin technology, but it is far from unique. Companies and governments across the world are realising the vast potential that digital twins have to allow complex and extensive counterfactual testing—with far lower ongoing costs, and far less environmental impact, than more traditional methods. It is particularly crucial for public-sector organisations at a time when the new government is looking to trim spending.

As the value of digital twins becomes more apparent, so does the plain fact that unlocking maximum value requires sharing values, technology, and data. One digital twin alone might be powerful, but how much more powerful would it be to combine digital twins built by different organisations, perhaps for different purposes?

However, doing so requires early implementation of a framework for sharing. The United Kingdom understood this when it became a relatively early adopter of digital twin technology. The Centre for Digital Built Britain—a partnership between the government and Cambridge University, which ran for five years until this September—led a national digital twin programme that aimed to coordinate development and ensure maximum value from digital twins. As part of a drive to create a national digital twin, knowledge and expertise has been shared, and continues to be shared, on a digital twin hub.

Places that are ahead of the game on digital twins are still relatively near the start of a journey, but are already beginning to understand the scale of the potential benefits. For example, Bradford council—which covers one of the most deprived, yet also one of the largest, metropolitan areas in the U.K.—has been working with the local University of Bradford to develop the country's first large-scale, open-source digital twin.

The council is already looking to use the outputs to create a masterplan to reinvent the city centre with new retail and residential buildings, monitor environmental improvements from a new Clean Air Zone levy on polluting traffic, and improve decision-making around planning.

The digital twin will also have a crucial role in planning and designing perhaps the most crucial infrastructure project in the city's recent history—a new high-speed station connecting Bradford to both Leeds and Manchester. So long as the government makes good on its promise to build the new line.