ASSOCIATION OF GEOSPATIAL INDUSTRIES

NEWSLETTER

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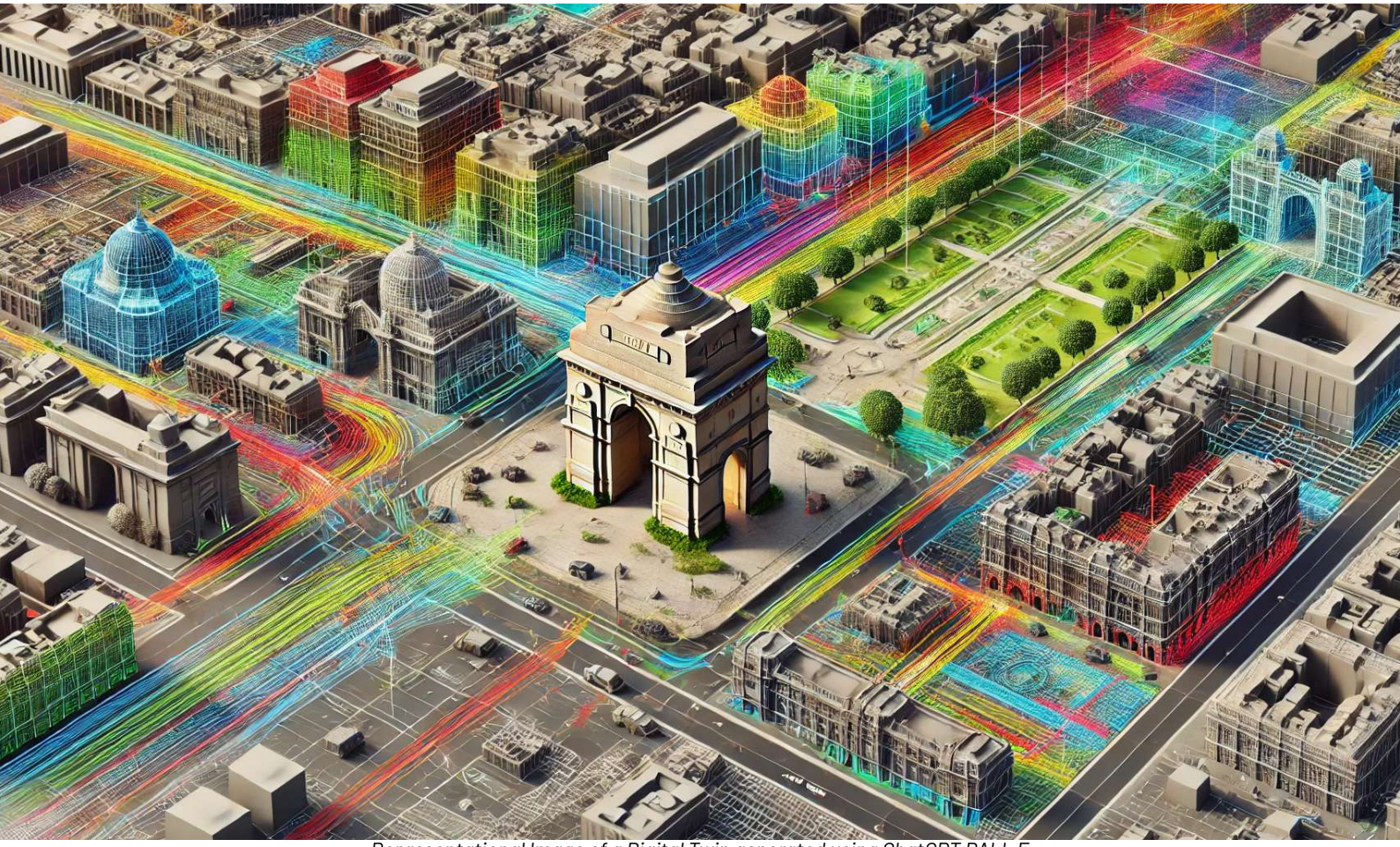

Representational Image of a Digital Twin generated using ChatGPT DALL·E

Theme: Demystifying Digital Twins

Editors' Note

Geospatial technology is experiencing a thrilling convergence with other disciplines, unlocking unprecedented insights into our world. We sit upon massive earth observation data making it possible to monitor the planet in real-time, track land cover changes, prepare for natural disasters, plan cities, and more. However, to truly grasp the planet's intricate dynamics and challenges, we need a more holistic approach.

That's where Digital Twin technology steps in - a groundbreaking concept that promises to revolutionize our notion and management of the planet. Digital Twin - a virtual mirror image of a physical entity - offers a dynamic, real-time simulation that integrates data from various sources, painting a comprehensive picture of our Earth's intricate systems.

Location, of course, is the cornerstone of any such endeavor.

Precise 3D location data is key to accurately representing our planet in the digital realm, adding a layer of complexity to the data collection process for rigorous environmental impact assessments, optimized sustainable infrastructure, and so on. The Indian government, recognizing the transformative potential of this technology, has outlined within the National Geospatial Policy 2022 the development of a National Digital Twin of India.

Its true power will lie in not just its ability to generate data, but in our ability to effectively communicate its insights to decision-makers. Many decision-makers may not be accustomed to thinking spatially when considering complex issues. By transforming complex geospatial data into compelling visualizations using the Digital Twin, we can empower informed decisions that shape the future of our planet.

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Message from the President's Desk

Nikhil Kumar
President - Geospatial, MapmyIndia

Digital twins, once a futuristic concept, are now becoming a reality, transforming industries across the globe. Beyond mere visualization, digital twins offer a dynamic and interactive platform for understanding, simulating, and optimizing complex systems. However, their true potential lies in their integration with geospatial technologies, offering a powerful tool for understanding, managing, and optimizing our physical world.

Geospatial digital twins offer a multitude of benefits. By providing a comprehensive understanding of spatial relationships, geospatial digital twins empower decision-makers to make informed choices. They enable planners to simulate different scenarios and evaluate the potential consequences of various interventions. Geospatial digital twins can be used to identify and assess risks, such as natural disasters or infrastructure failures. They support sustainable development by enabling the analysis of environmental impacts and the optimization of resource use.

The Indian government's National Geospatial Policy plays a crucial role in driving the development and adoption of geospatial digital twins. By promoting the creation of a National Digital Twin of India, the policy aims to harness the power of geospatial data to address various national challenges.

The National Digital Twin will serve as a comprehensive digital representation of the country, encompassing its physical infrastructure, natural resources, and socio-economic conditions. By leveraging geospatial technologies, the twin will provide valuable insights into urban planning, disaster management, and sustainable development.

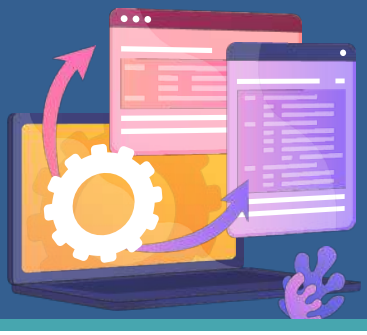
At the Association of Geospatial Industries (AGI), our mission has always been to promote and advance both the Geospatial industry and Geospatial technologies and applications in India. As a forum for exchanging ideas, techniques, approaches, and experiences by those who design, implement, and use Geospatial technology solutions, AGI dedicates this Edition of its newsletter to the theme of "Demystifying Digital Twins" through the Geospatial lens.

We hope this Edition comes across as insightful and enjoyable. Stay tuned for more insights, stories, and analyses from AGI in the coming months.

Enjoy Reading,

Nikhil Kumar
President, AGI.

Updates from AGI



Launch of Special Defence Committee

Oct 2024: AGI announced the formation of a Special Defence Committee under its aegis, chaired by Major General RC Padhi and co-chaired by AGI Senior Vice President Sreeramam G V. This committee aims to address the critical need for enhanced Geospatial technology adoption in the Indian defence sector with a 360-degree consultative approach.

Industry Interaction with GDPDC

Oct 2024: AGI hosted an exclusive interaction between GDPDC Chair Mr. Srikant Sastri and AGI members on the present and future of Geospatial technologies in New Delhi. The GDPDC chair spoke about demand generation as one of the primary focus areas for the committee, implementing the vision of the National Geospatial Policy 2022, and the vision behind Operation Dronagiri in 5 pilot districts, followed by an interactive discussion strengthening the Geospatial data and knowledge infrastructures, and industry role and development.

Survey of India – Industry Interaction

Sep 2024: Survey of India (SOI), as the technical partner for the Department of Land Resources (DoLR) NAKSHA scheme for mapping urban areas across states as a pilot, had an industry interaction regarding readiness for Aerial Survey using nadir, oblique, oblique + LiDAR sensors onboard manned or unmanned aerial platforms, chaired by the Surveyor General of India. AGI facilitated the interaction for its members, followed by a consolidated response on industry readiness and feedback.

Webinar on Accelerate Digital Transformation in GIS for Land Mapping & Urban Development Using Drone Technology and Data Analytics

Sep 2024: AGI hosted a thematic webinar, sponsored by AGI member Asteria Aerospace, on how the GIS service industry can leverage drone technology and data analytics to meet Union Budget 2024's ambitious goals. Tailored for GIS professionals, urban planners & policymakers, and drone technology professionals, the webinar had speakers from AGI, Asteria Aerospace, and the Survey of India and was received well by audiences.

Lecture on Industry Perspectives to NGP 2022 at NIGST Campus

Sep 2024: AGI Senior Vice President Sreeramam GV delivered a special address on the National Geospatial Policy 2022 at NIGST, Hyderabad, on the salient features of the policy, industry sentiment, feedback, and concerns, the industry's response in terms of increasing innovation, boosting startups, and augmented investments and hiring by larger companies, and detailed strategies for the successful implementation of the policy for various stakeholders.

National Workshop on Strengthening the Geospatial Ecosystem

Nov 2024: Policymakers, experts and industry leaders came together to discuss ways to advance India's geospatial sector in alignment with the National Geospatial Policy (NGP) 2022 at the National Workshop on Strengthening the Geospatial Ecosystem hosted by Survey of India and supported in various capacities by AGI. Participants explored the collaborative roles of central ministries and state governments in implementing NGP-22. The event also highlighted the impact of Operation Dronagiri, launched on 13th November 2024.

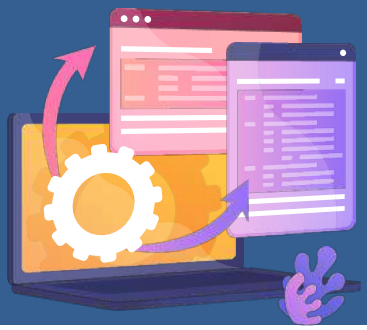
UN-GGIM Asia-Pacific Regional Conference on Geo-Enabling Data Economy for Sustainable Development

Nov 2024: AGI extended its support for the successful conduction of the UN-GGIM AP 2024 Regional Conference in New Delhi, with AGI President Shri Nikhil Kumar representing the Indian Geospatial industry's views on how thematic networks can support the delivery of the UN-GGIM agenda. Mr. Nikhil Kumar talked about how the private sector can contribute more effectively to advancing the UN-GGIM agenda, particularly in achieving the Sustainable Development Goals (SDGs) through geospatial technologies.

International Workshop on Modern Technologies in Survey-Resurvey for Urban Land Records

Oct 2024: AGI President Shri Nikhil Kumar delivered an address in the session on "Advanced Land Mapping with Accurate and Efficient ORI Generation" at the International Workshop on Modern Technologies in Survey-Resurvey for Urban Land Records, hosted by the Department of Land Resources (DoLR), chaired by Surveyor General of India Shri Hitesh Makwana.

Events Roundup



AGI at GeoSmart India 2024

Dec 2024: Several AGI members participated at the GeoSmart India 2024 annual conference, hosted by AGI member Geospatial World in Hyderabad. AGI member companies were represented by plenary and session speakers & panelists, exhibitors, and delegates at the event.

GeoSmart India brought together government officials, geospatial specialists, the IT industry experts, and end-users to collaboratively explore and implement innovative, technology-driven governance solutions. GeoSmart India was co-located with two major events: AEC Forum and Bilateral Summits.

Supported Events

- Associate Partner for Drone Expo and Conference 2024 by Services International
- Institutional Partner for CEPT Earth Observation Symposium organised by CEPT University, Ahmedabad
- Supporting Association for Times Now Global Sustainability Alliance SDG Summit 2024 by ET Edge
- Supporting Partner for Indian Space Conclave 2024 by Indian Space Association

For queries on memberships/partnerships, write to sakshi.singh@agiindia.com

Product Portfolio: Maxar Technologies

Maxar's 3D Foundation for Urban Digital Twins

With 125+ petabytes of data in its global imagery library, and 3.8M square kilometers of high-resolution imagery collected daily, satellite Earth observation company Maxar Intelligence has created a living, accurate representation of The Globe in 3D.

Pairing its massive satellite imagery archive with its patented 3D technology enables Maxar to provide a precise representation of Earth. This approach combines decades of deep mission understanding and a proven foundation of commercial technology to deliver solutions with speed, scale, and cost-effectiveness.

Maxar's products are ideal for supporting smart city initiatives throughout India with digital twin development. Digital twins can facilitate relevant planning, modeling, implementation, and maintenance for initiatives such as infrastructure, utilities, law enforcement, traffic management, public transportation, and more.

A Precise 3D Data Suite: Maxar's Precision3D (P3D) Data Suite, part of The Globe in 3D product portfolio, offers a foundation to generate digital twins of urban environments. Civil agencies and local governments around the world rely on P3D's data and elevation models for urban governance, utility planning, maintenance, property taxation, disaster planning, and more. For example, planning and resource management professionals can leverage P3D data to measure and calculate slope, aspect, volume, and flood fill levels to plan for, prepare for, and prevent disasters like landslides and floods.

Imagery & Analytics On-Demand: The Maxar Geospatial Platform (MGP) Pro offers another way to access the company's 2D data as well as 3D data for digital twin development. This subscription-based service provides on-demand access to high-accuracy, high-resolution imagery and analytics. Key highlights include:

- An extensive historical archive and premium imagery, including up to 30 cm resolution and 4 m CE90 accuracy.
- Coverage at 50 cm resolution or better worldwide, including denied areas.
- A rapid refresh rate over the areas of interest that matter most.
- Ready-made base maps for seamless integration with existing geospatial platforms.
- P3D capabilities for terrain analysis.
- Online analytic tools for image processing and exploitation.
- Customized flexibility such as simple APIs, OGC streaming services, web interface, and GIS integrations.

MGP Pro is designed to support a wide spectrum of e-Governance use cases, including urban and rural development, agriculture and forestry, and natural disaster management. This versatility makes MGP Pro an effective, innovative solution for governments looking to enhance decision-making and operational efficiency across various sectors.

NGP vision of creating a National Digital Twin for all major cities and towns by 2035 transformative.

Multi-stakeholder approach built on collaboration, R&D investment, and robust governance frameworks is key, notes **Mr Nikhil Kumar, President - Geospatial, MapmyIndia**

"Demystifying" the digital twin concept, what are some myths that you would like to bust about the technology?

The term 'digital twin' often gets thrown around, but its true essence lies in its ability to create a dynamic, data-driven virtual replica of a real-world entity. This isn't just about 3D modeling; it's about integrating real-time data streams from sensors, IoT devices, and other sources to create a living, breathing representation.

For instance, in the field of Geospatial, we can leverage this to create digital twins of entire cities. The virtual model can reflect real-time traffic patterns, energy consumption, and even environmental conditions. This allows for predictive analysis, enabling city planners to anticipate challenges and optimize infrastructure.

That said, there are some common misconceptions around the concept of digital twins that need to be addressed.

One common myth many users have is that Digital twins are usable solely in the manufacturing sector. That is not true. While manufacturing has been a significant driver, their applications extend far beyond the factory floor. In Geospatial, they are crucial for urban planning, disaster management, and even precision agriculture.

Another myth is that digital twin technology is overly complex and expensive. The reality is that while initial development can have a cost, the long-term benefits in terms of efficiency and reduced risk often outweigh the investment.

Moreover, advancements in cloud computing and the availability of open-source tools are making them more accessible.

Another myth yet is that the digital twin is merely a futuristic concept with limited practical applications today. This couldn't be further from the truth. Many successful implementations exist across various sectors. In our field, we're seeing real-world applications in areas like smart transportation, environmental monitoring, and even archaeological site preservation.

While initial development can have a cost, the long-term benefits in terms of efficiency and reduced risk often outweigh the investment.

While cityscape-level digital twins are much talked about from an infrastructure management point of view, an interesting application lies in indoor space simulations in real-time. How game-changing is this technology for a country like India?

The potential of real-time indoor space simulations within the framework of digital twin technology is truly significant for a nation like India. Given the rapid urbanization and increasing popilation

density, efficient management of indoor spaces in densely populated areas becomes paramount. Digital twins can revolutionize this by providing a dynamic, data-driven representation of indoor environments, enabling optimized operations across various sectors. Here are a few examples:

Healthcare

Digital twins can stimulate patient flow within hospitals can optimize resource allocation, minimize wait times, and ultimately enhance the overall patient experience.

Retail

Digital twins can be used to analyze customer movement patterns within malls. This can inform strategic decisions regarding store layouts, product placement, and overall customer experience.

Emergency Management

Evacuation scenarios can be simulated in high-rise buildings to identify potential bottlenecks and optimize emergency response plans, saving valuable time and potentially lives

Internal Security

digital twins can be employed to model and simulate complex scenarios within critical infrastructure such as airports, railway stations, and government buildings. This enables proactive identification of vulnerabilities, optimization of security protocols, and swift response to potential threats.

Transportation

Digital twins can optimize the design and operation of transportation hubs such as airports and railway stations. By simulating passenger flow, identifying congestion points, and optimizing resource allocation, these digital twins can enhance the overall travel experience and improve operational efficiency.

Logistics

By simulating the flow of goods and people within logistics hubs, warehouses, and transportation nodes, bottlenecks can be identified and mitigated, leading to more efficient and cost-effective movement of goods across the country. The PM Gati Shakti National Master Plan, aimed at creating a seamless and integrated infrastructure ecosystem, can significantly benefit from the application of indoor space digital twins.

MapmyIndia's partnership with Dassault Systèmes Collaborates to design and deliver sustainable public services using digital twins is much talked about. Please share some insights into the collaboration.

The collaboration between MapmyIndia Mappls and Dassault Systèmes holds immense potential for India's urban development. By combining MapmyIndia's deep expertise in location intelligence and geospatial data with Dassault Systèmes' powerful 3DEXPERIENCE platform, this partnership aims to create comprehensive and dynamic digital twins of Indian cities.

Image source: MapmyIndia

This synergy will enable the development of end-to-end solutions for critical areas such as smart urban infrastructure, transportation, utilities management, and public safety. The platform, with its ability to gather, organize, and analyze vast amounts of data from various sources, will provide a holistic view of the urban ecosystem, enabling stakeholders to make informed decisions and plan for a more sustainable future.

MapmyIndia Mappls, with its extensive and high-definition geospatial data

> **MapmyIndia's deep expertise in location intelligence and geospatial data with Dassault Systèmes' powerful platform... aims to create comprehensive and dynamic digital twins of Indian cities.**

including 3D, 4D, and even 360-degree imagery, provides the foundational layer for these digital twins. This data, captured through advanced sensors and processed using AI/ML, forms the backbone of these virtual representations, enabling accurate and realistic simulations.

The collaboration aligns perfectly with India's national development initiatives, including the Smart Cities Mission, Gati Shakti, and the National Infrastructure Pipeline. By leveraging digital twin technology, cities can optimize infrastructure, improve resource utilization, and enhance the overall quality of life for their citizens. Furthermore, the 'real-to-virtual/virtual-to-real' feedback loop inherent in this approach allows for continuous improvement. By constantly updating the digital twin with real-world data, cities can refine their planning and operations, ensuring that their infrastructure remains resilient and adaptable to evolving needs.

One of MapmyIndia's most celebrated offerings is your advanced connected vehicle IoT platform that produces a digital twin of the vehicle. What features does this platform provide and what is the user response like?

Our connected vehicle IoT platform is a cornerstone of our offerings, enabling us to create a dynamic digital twin of each vehicle. This isn't just about tracking location; it's about understanding the vehicle's entire lifecycle in real time. Key features of the platform include:

- **Real-Time Vehicle Tracking & Monitoring:** Precise location tracking, real-time speed and fuel consumption data, and the ability to monitor vehicle health parameters..

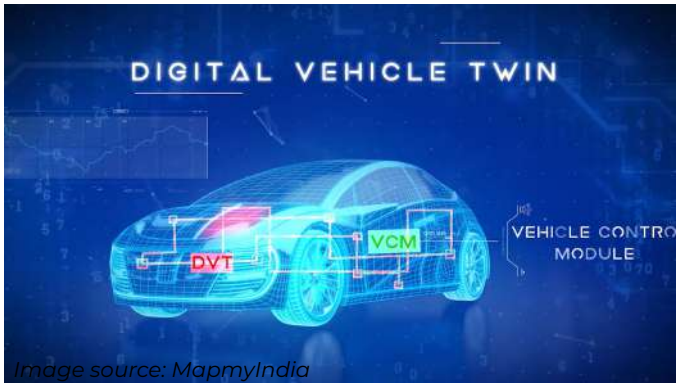


Image source: MapmyIndia

- **Driver Behavior Analytics:** Analyzing driver behavior patterns, such as harsh braking, rapid acceleration, and excessive idling, to improve driving efficiency and safety.
- **Predictive Maintenance:** Leveraging data analytics to predict potential maintenance issues, minimizing downtime and optimizing vehicle maintenance schedules.
- **Fleet Management Optimization:** Optimizing route planning, improving fuel efficiency, and enhancing overall fleet utilization.
- **Enhanced Safety Features:** Implementing advanced safety features such as emergency alerts, remote immobilization, and driver fatigue detection.

The user response to this platform has been overwhelmingly positive. Customers, ranging from individual vehicle owners to large fleet operators, appreciate the valuable insights and operational efficiencies it provides. For instance, fleet operators are leveraging the platform to reduce fuel costs, improve driver safety, and enhance overall fleet productivity. Individual vehicle owners are benefiting from enhanced safety features, improved navigation, and a better understanding of their driving habits. This platform is a testament to our commitment to developing innovative solutions that leverage the power of location intelligence and connected technologies to transform the automotive landscape in India.

A digital twin is as good as the data sources it relies on. How are MapmyIndia's advanced map SDKs shaping this mapping innovation for industries?

The accuracy and granularity of a digital twin are indeed directly tied to the quality of the underlying map data. This is where MapmyIndia's advanced map SDKs play a crucial role.

Our SDKs are built upon a foundation of decades of expertise in mapping India. We've meticulously created a comprehensive and constantly evolving map dataset, encompassing detailed road networks, accurate addresses, extensive Points of Interest (POIs), and real-time traffic information. This robust foundation provides the necessary granularity and accuracy for developers to build highly sophisticated and reliable digital twins.

Here's how our SDKs contribute to this mapping innovation:

Comprehensive and Accurate Data

Our SDKs provide access to the most up-to-date and comprehensive map data, ensuring that the digital twins created are reflective of the real world.

Enhanced User Experience

By integrating our SDKs, developers can enhance user experiences with features like real-time navigation, location-based services, and immersive 3D map visualizations.

Industry-Specific Solutions

Our SDKs are versatile and can be tailored to meet the specific needs of various industries, enabling the creation of industry-specific digital twins for sectors like transportation, logistics, and urban planning.

Continuous Innovation

We are constantly updating and improving our map data and SDKs, incorporating the latest advancements in mapping technologies like AI/ML, computer vision, and IoT.

By providing developers with access to high-quality map data and powerful SDKs, MapmyIndia is empowering them to create more accurate, insightful, and impactful digital twins that drive innovation across a wide range of industries.

India's National Geospatial Policy 2022 stresses the creation of a National Digital Twin for all major cities and towns by 2035 under its vision and goals. What are the major technical and governance challenges you see that need to be addressed to implement this vision?

The National Geospatial Policy 2022's vision of creating a National Digital Twin for all major cities and towns by 2035 is an ambitious and transformative goal. However, realizing this vision will require addressing several significant technical and governance challenges.

Major technical challenges include seamlessly integrating data from diverse sources, including government agencies, private companies, and citizen-generated data. Ensuring data interoperability and establishing common data standards will be crucial for creating a unified and comprehensive digital twin. The digital twin will also require continuous updates with

Image source: MapmyIndia

real-time data from various sources – hence developing robust and scalable systems for real-time data acquisition, processing, and integration will be critical. At the same time, creating and maintaining high-fidelity digital twins of complex urban environments calls for investing in high-performance computing resources with reliable data storage and processing capabilities.

A multi-stakeholder approach is key to realizing the vision of a National Digital Twin for all major cities and towns.

Governance challenges can be solved with clear guidelines for data ownership, access, and sharing among stakeholders. Effective coordination and collaboration among various government agencies, including urban planning departments, transportation authorities, and emergency response agencies, is also essential.

Finally, a skilled workforce with expertise in digital twin technologies, data science, and geospatial analysis will be critical for the successful implementation and maintenance of these complex systems. A multi-stakeholder approach built on collaboration, R&D investment, and robust governance frameworks is key to realizing the vision of a National Digital Twin for all major cities and towns.

Article: Esri India

ArcGIS—The Backbone of Digital Twins

Digital twins create a representation of both natural and built environments, allowing stakeholders to monitor current performance while also exploring and predicting future outcomes. The advantages of digital twins significantly increase when GIS data is incorporated.

This integration enhances visualization and analytical capabilities, enabling users to gain valuable insights into various scenarios and their potential impacts. Improved access to data facilitates faster decision-making and boosts workflow efficiency.

Digital Twin Life Cycle

An integrated digital twin enabled through a modern GIS is not one single solution or product—rather, it is an ecosystem of capabilities and applications being bought together by GIS to support holistic and collaborative approaches. It is not one digital twin but rather many digital twins that are integrated and interconnected.

Below are the four elements for managing the information lifecycle for a digital twin:

Data capture and integration are foundational to a digital twin. Organizations need comprehensive, end-to-end data management. They need to capture the data, model it, integrate it, and then manage it and its associated attributes and behaviors throughout its lifecycle.

Real-time and visualizations bring the data to life, taking information and creating a better understanding of what is happening now. Sensor technology enables real-time situational awareness combined with advanced visualization capabilities to virtually represent how the physical components are operating in the real world.

Analyze and predict to move decision-making beyond just understanding the current operational state. Organizations must understand the past and view predictions of the future. They need to simulate and forecast expected outcomes as well as automate the decision-making process.

Sharing and collaboration are enabled via desktop and mobile devices for both internal and external stakeholders. Digital twins are about collaboration, sharing information, and getting it to those who need it, when they need it.

Esri's ArcGIS enhances data capture and integration, enables better real-time visualization, provides advanced analysis and automation of future predictions, and allows for information sharing and collaboration.

The Five Levels of Digital Twins

Digital twins can be classified into five levels of sophistication, ranging from basic data integration to fully autonomous operation.

Level 1: Descriptive Twin: The descriptive twin serves as a live, editable representation of design and construction data, providing a visual replica of a built asset. Users can choose the information to include and the data to extract, effectively creating a virtual model of physical assets or networks.

Level 2: Informative Twin: Building on the descriptive twin, the informative twin incorporates operational and sensory data. It aggregates and verifies data from various sources, ensuring that systems work together seamlessly and in real-time.

Level 3: Predictive Twin: At this level, the predictive twin leverages operational data to generate insights and forecast outcomes, enhancing decision-making capabilities.

Level 4: Comprehensive Twin: The comprehensive twin takes it a step further by simulating future scenarios and exploring "what-if" questions. It provides outcome simulations that inform recommendations.

Level 5: Autonomous Twin: The most advanced level, the autonomous twin, can learn and act independently on behalf of users. It features self-learning capabilities and can make decisions without human intervention.

Image source: Esri India

ArcGIS Fuels Living Digital Twins

A digital twin brings together many adjacent yet distinct worlds. Central to a living digital twin is the 3D System, which provides clarity, new perspectives, and connectivity to foster sustainable workflows for complex and evolving challenges.

What makes ArcGIS unique is that it integrates and connects all these different types of information models and digital twins. ArcGIS allows users to go beyond using very detailed building information models of structure interiors, to see the buildings' relationships to networks and see all this in context next to the larger city views.

Geospatial digital twins, developed with ArcGIS, can be accessed on mobile devices, web browsers, or through advanced desktop applications from Esri and its partners. Additionally, GIS data drives numerous simulations that reflect real-world dynamics and behaviors. For straightforward analyses, such as assessing shadow impacts on proposed structures, 3D GIS offers intuitive, interactive experiences directly in web browsers. For more intricate analyses, advanced geoprocessing workflows can simulate changes in extensive utility networks, displaying results in user-friendly dashboards.

Conclusion

The emergence of Industry 4.0 and IoT has accelerated the adoption of the digital twin technology across industries. Players in the automotive, aerospace, and defense industries appear to be more advanced in their use of digital twins today, while logistics, infrastructure, and energy players are gearing up to follow suit soon.

Organizations across verticals are increasingly exploring ways to deploy digital twins in a variety of ways, including in operations, city planning, smart infrastructure, and much more.

GIS technology has a very important role in advancing the idea of creating digital twins for the infrastructure sector in the country. Any digital twin of a fixed asset or real-world system benefits directly from including GIS data about the asset or system and its geographic context.

Not only can GIS be used to create digital twins of natural and built environments, but it also can be used to integrate many different digital representations of the real world.

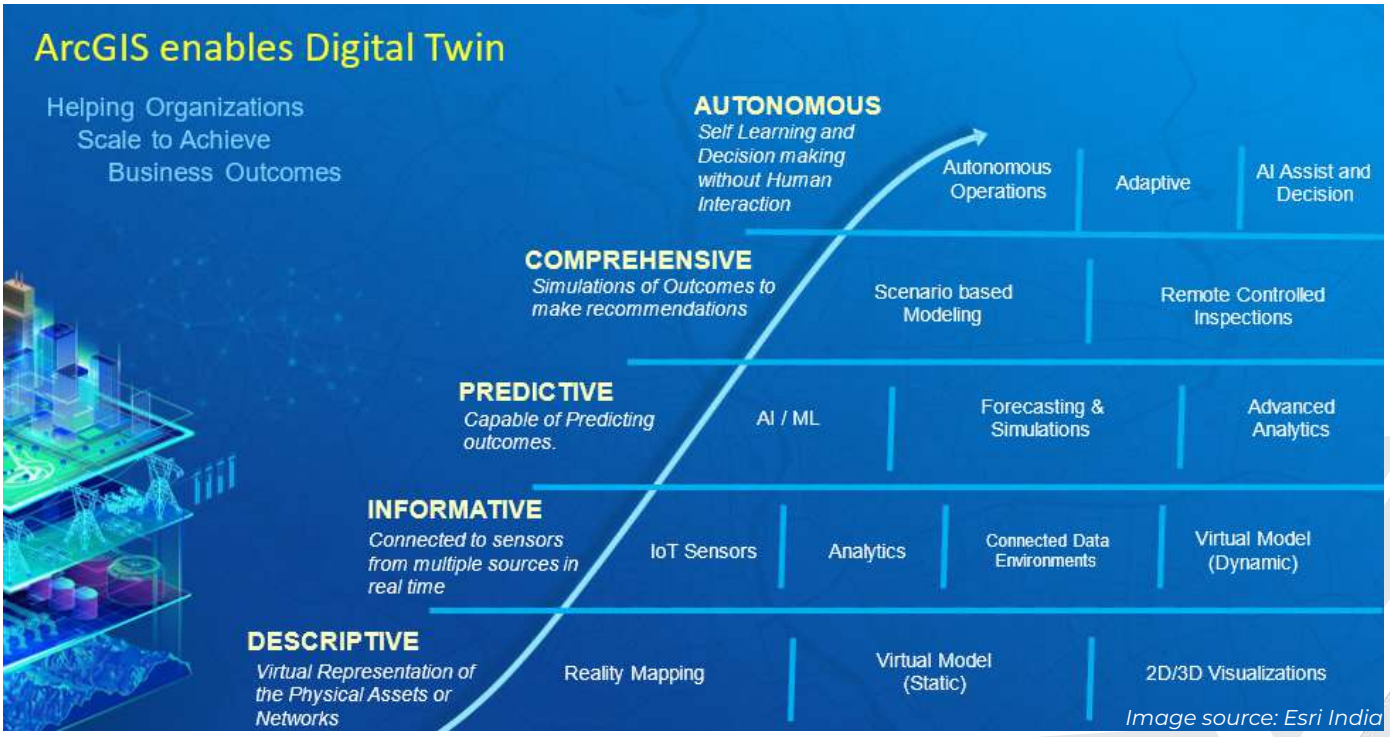
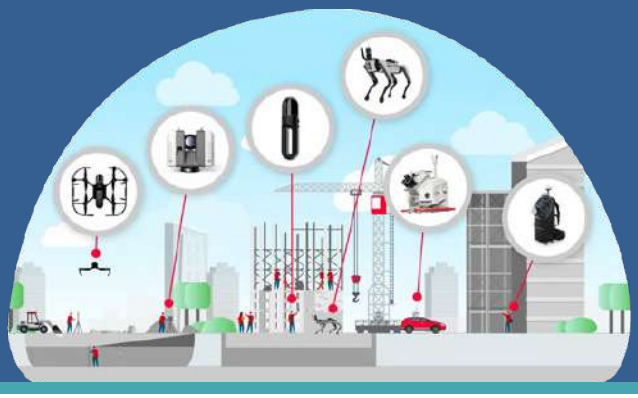


Image source: Esri India

Article: Hexagon

Decoding Digital Twins: Hexagon's Approach to Mastering Virtual Replicas



The term Digital Twin was first introduced in a white paper by Dr. Michael Grieves (University of Michigan) in 2002. A digital twin is a virtual representation of a real-world asset or system. It serves as a bridge between the physical asset and the digital world, facilitating the collection and processing of asset data and enabling insights that are not normally attainable. A digital twin is a digital depiction of its physical counterpart, including all its dynamics. It replicates not only the physical object but also its behavior and entire life cycle.

The digital twin can help solve physical issues more quickly by detecting them sooner, predict outcomes with greater accuracy, design and build better products, and, ultimately, serve the cause more effectively. It leverages data from sensors, simulations, and models to keep the virtual model continuously updated, enabling organizations to monitor, analyze, and enhance the performance of the physical entity.

Key Components of a Digital Twin

- **Physical Object/Process:** The real-world entity that the digital twin represents.
- **Digital Replica: A** virtual model constructed using technologies such as 3D modeling, artificial intelligence (AI), and machine learning (ML).
- **Data and Connectivity:** Continuous data flow from the physical object to the digital twin, typically enabled by the Internet of Things (IoT) sensors.
- **Analysis and Simulation:** The digital twin can simulate various scenarios, forecast outcomes, and test improvements without disrupting the physical object.
- **Feedback Loop:** Insights from the digital twin can be applied back to the physical entity to optimize its performance.

Types of Digital Twin:

1. Static Digital Twin

A static digital twin is a digital replica of a physical object, system, or process created at a specific point in time and does not receive continuous data updates. It serves as a fixed reference model for visualization or analysis.

Benefits: Provides a detailed snapshot of the physical entity at a particular moment.

Examples:

- A 3D model of an ancient artifact created via photogrammetry that doesn't update in real-time.
- A digital model of a building created during its design phase but not updated after construction.

2. Connected Digital Twin

A connected digital twin is a dynamic model that continuously receives data from its physical counterpart through sensors and IoT devices. It offers real-time monitoring and feedback, reflecting ongoing changes in the physical object or system.

Benefits: Real-time data enables continuous monitoring, maintenance, and operational improvements.

Examples:

- A smart city digital twin that monitors traffic, weather, and energy usage in real-time.
- A digital twin of a wind turbine that continuously tracks performance metrics to optimize energy output and predict maintenance needs.

3. Intelligent Digital Twin

An intelligent digital twin extends the capabilities of a connected digital twin by integrating advanced technologies such as artificial intelligence (AI), machine learning (ML), and data analytics. It not only receives real-time data but also processes and analyze this information to make predictions, optimize processes, and, in some cases, make autonomous decisions or recommendations.

Benefits: Delivers actionable insights through data analysis and predictive modeling.

Examples:

- An intelligent digital twin of a self-driving car that learns from driving conditions and adapts its behavior based on real-time data and predictive algorithms.
- A digital twin in healthcare that models a patient's organs and utilizes AI to predict disease progression and recommend personalized treatments.

Applications Across Industries

Manufacturing: Digital twins have transformed the manufacturing sector by optimizing production processes and reducing costs. A digital twin of a machine or an entire production line can predict maintenance needs, minimize downtime, and enhance efficiency.

Urban Planning and Smart Cities: Urban planners and municipalities are leveraging digital twins to improve infrastructure and resource management. By creating digital replicas of cities, they can help improve infrastructure and resource management.

Archaeology: In archaeology, digital twins are used to create replicas of archaeological sites, artifacts, and monuments. This technology allows researchers to monitor, analyze, and preserve historical heritage in ways never before possible. It enables the exploration and protection of the past while using cutting-edge technology to engage the public and ensure the preservation of fragile historical sites.

Energy and Utilities: In the energy sector, digital twins are widely used to optimize performance and maintenance for power plants, wind turbines, and grids. By creating digital replicas of energy assets, operators can predict equipment failures, enhance energy efficiency, and reduce environmental impacts.

Aerospace and Automotive: The aerospace and automotive industries have adopted digital twins to improve the design, production, and maintenance of aircraft and vehicles. In aerospace, digital twins of aircraft engines provide real-time data on performance and potential failures, resulting in increased safety and efficiency.

Advantages of Digital Twins

Predictive Maintenance: One of the most valuable features of digital twins is their ability to predict equipment failure and maintenance needs. This capability helps reduce downtime and extend the lifespan of assets.

Cost Efficiency: By simulating changes and improvements in the digital realm, businesses can avoid costly mistakes and inefficiencies in the physical world.

Faster Innovation: Digital twins accelerate innovation by enabling faster design iterations and more accurate testing. This is especially beneficial in industries such as aerospace, automotive, and manufacturing.

Enhanced Decision-Making: Real-time data analytics from digital twins empower organizations to make informed decisions that enhance performance, safety, and sustainability

Risk Mitigation: Digital twins allow companies to identify potential risks and test responses in a virtual environment before implementing real-world actions.

The Future of Digital Twins

As IoT, AI, and data analytics continue to advance, digital twins are expected to become more sophisticated, with their applications broadening. The future of digital twins involves managing more complex systems, such as entire cities, global supply chains, and autonomous vehicles. The rollout of 5G networks will further enhance digital twins by providing faster, more reliable data transmission, which will enable real-time simulations and more accurate predictions.

Moreover, the emerging concept of cognitive digital twins is gaining momentum. In this model, AI algorithms empower the digital twin to learn from its environment and make autonomous decisions or suggest optimizations. This could revolutionize industries like manufacturing, healthcare, and urban development, where real-time decision-making is critical.

Conclusion

The digital twin revolution is just beginning, with immense potential to transform industries. From optimizing manufacturing processes to enhancing healthcare outcomes, the creation of a virtual counterpart for physical systems opens new avenues for innovation, efficiency, and sustainability. As digital twin technology continues to mature and address challenges such as scalability and cybersecurity, it is set to become an integral part of the digital transformation journey for businesses across the globe.

Article: MapmyIndia

Demystifying Digital Twins: The Future of 3D Modelling and Real-World Applications

As the digital age progresses, the concept of a "Digital Twin" has emerged as a game-changer across industries. While often associated with engineering and urban development, its potential reaches far beyond, creating a tangible link between physical and digital realms. But what exactly is a Digital Twin, and why should businesses and governments invest in this transformative technology?

What is a Digital Twin?

A Digital Twin is a virtual replica of a physical object, system, or environment, created using real-time data and advanced simulation techniques. It allows stakeholders to visualize, simulate, and analyze the performance of physical assets in a digital format. Starting from infrastructure and urban environments to machinery and even biological systems, Digital Twins enable a more interactive, data-driven approach to managing and improving assets.

At its core, a Digital Twin is fuelled by various technologies, including 3D models, photogrammetry, LiDAR, virtual models, and BIM. The interplay of these technologies forms the foundation of Digital Twins, making them invaluable tools for industries like construction, urban planning, energy management, and many more.

Advantages of Investing in Digital Twin

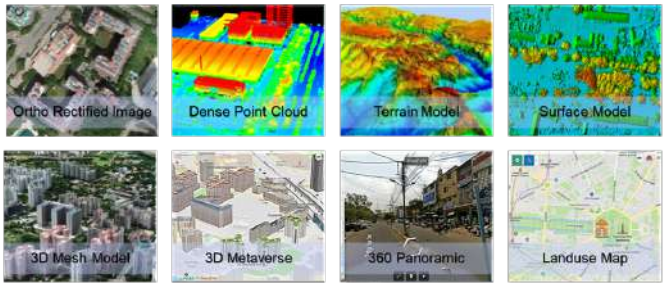
For organizations managing complex assets, a Digital Twin provides real-time visibility into performance, potential issues, and future scenarios. This can lead to:

Improved Decision Making: A Digital Twin offers insights based on real-time data, simulations, and predictive analytics, enabling informed decisions.

Cost Reduction: By simulating various scenarios, Digital Twins help optimize maintenance, resource allocation, and energy usage, resulting in cost savings.

Risk Mitigation: Simulating different "what-if" scenarios helps in assessing risks, preventing potential failures, and increasing resilience.

Sustainability and Efficiency: Optimizing asset performance and energy consumption through real-time monitoring contributes to sustainability goals.



Predict Outcomes: Digital Twins use historical data to forecast potential issues, allowing stakeholders to proactively address problems.

As industries grapple with the complexities of urbanization, environmental sustainability, and asset management, the adoption of Digital Twins is increasingly seen as a forward-looking solution.

Building the Digital Twin

Photogrammetry and LiDAR: Precision in 3D Modelling

The process of creating a Digital Twin begins with capturing the physical environment. This is where photogrammetry and LiDAR play pivotal roles.

- **Photogrammetry** captures high-resolution images from multiple angles to create accurate 3D models. This method is ideal for large-scale environments like cities or construction sites, offering a detailed representation of real-world objects.
- **LiDAR** uses laser pulses to map environments with pinpoint accuracy. Whether airborne or terrestrial, LiDAR is especially useful for detailed mapping of complex structures like heritage sites, bridges, and densely forested areas. The laser pulses generate point clouds, which can then be converted into precise 3D models.

3D models provide the spatial accuracy needed to replicate real-world objects and environments, forming the core of many Digital Twin applications. From monitoring infrastructure like bridges and roads to mapping natural landscapes, the combination of photogrammetry and LiDAR brings a high level of realism to Digital Twins. Together, these technologies form the spatial backbone of

Digital Twins, enabling industries to visualize physical environments in real time.

Virtual Models and 360-Degree Visualization: Enhancing the Digital Experience

Digital Twins go beyond mere accuracy. They also offer interactive visualization through virtual models and 360-degree imagery. These tools allow users to explore digital environments as if they were physically present. For example, in urban planning, 360-degree imagery enables stakeholders to virtually walk through a proposed development before any construction begins. In real estate, potential buyers can tour properties remotely, gaining an immersive understanding of spatial layouts. Combined with photogrammetry and LiDAR data, these virtual environments create detailed representations that can be manipulated and analyzed.

Scan-to-BIM: Bridging Physical and Digital Worlds

Scan-to-BIM technology takes Digital Twins a step further by integrating real-world 3D scans into the BIM process. This integration ensures that Digital Twins reflect real-world conditions down to the finest details, providing project teams with an accurate model for design, construction, and operation. For infrastructure projects, Scan-to-BIM delivers real-time updates that allow project managers to compare the actual progress with design plans. Any discrepancies between physical construction and design can be identified early, minimizing delays and ensuring projects stay on track.

Benefits of Digital Twins

Improved Efficiency: Continuous monitoring and real-time data feedback allow organizations to streamline operations and reduce inefficiencies.

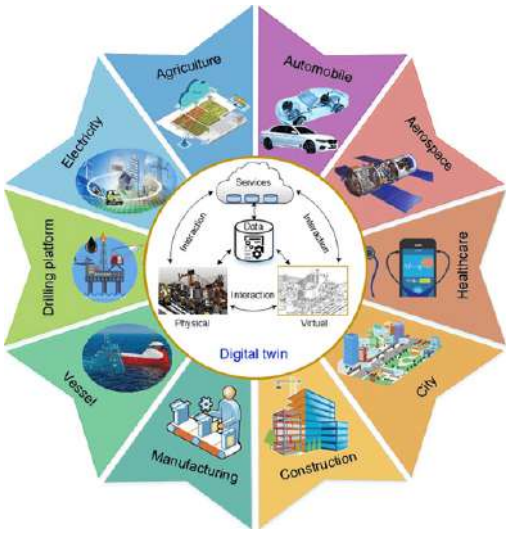
Enhanced Predictive Maintenance: By predicting when equipment is likely to fail, Digital Twins minimize downtime and extend the lifespan of physical assets.

Sustainability: Digital Twins help reduce waste and optimize energy use for more sustainable operations.

Collaboration and Decision-Making: Real-time data sharing across departments and teams ensures that decisions are based on accurate, current information.

Use Cases and Examples

Urban Planning: Municipalities are leveraging Digital Twins to simulate traffic flows, monitor infrastructure conditions, and optimize urban development. City planners can visualize how proposed changes will impact transportation networks or residential areas, enhancing long-term planning.



Infrastructure planning: In industrial environments, Digital Twins monitor factory equipment and production lines. This not only improves operational efficiency but also helps predict machine failures, thereby minimizing downtime.

Disaster Management: The integration of GIS with hi-tech drone technology provides a comprehensive solution for disaster preparedness, response, and recovery. GIS offers a spatial framework for mapping and analyzing critical infrastructure, while drone technology contributes real-time data and high-resolution imagery, facilitating the preparation of 3D virtual cities.

Encroachment Analysis: The 3D virtual city models generated through this process offer a comprehensive visual representation, aiding in the formulation of informed decisions for encroachment prevention and resolution.

Water supply network management: GIS provides a spatial framework for mapping and analyzing water distribution systems, while drone technology offers real-time updates and high-resolution imagery, contributing to the preparation of 3D virtual cities

Conclusion

Digital Twins represent the future of asset management and urban development. The combination of photogrammetry, LiDAR, virtual models, and Scan-to-BIM brings unparalleled accuracy and interactivity to the table, making Digital Twins an essential tool for tackling today's complex challenges.

Digital Twins in Urban Environment: Shaping Smart Cities through Virtual Replicas

The concept of Digital Twins in the urban environments, powered by GIS analytics, has gained significant momentum in recent years. This growth is accentuated by advancements in data acquisition technologies and computation capabilities for processing large volumes of data. As these technologies continue to evolve, Digital Twins are gradually becoming the benchmark for city planning, management and sustainability

Understanding Digital Twins

A digital twin is a virtual replica of a physical entity, such as a building, infrastructure, or even an entire city, created using data and analytics. This virtual replica is designed to mimic the behaviour and characteristics of its physical counterpart, allowing for real-time monitoring, simulation, and analysis.

The concept of "twins" originated from NASA's Apollo program (1961-1972), where identical space vehicles were constructed to simulate mission conditions. This idea evolved further in the manufacturing industry, where digital replicas were created to optimize production and predict maintenance needs. The term "Digital Twin" was first coined in 2002 by Professor Grieves during his Product Lifecycle Management (PLM) course at the University of Michigan. Since then, its application has expanded into various fields.

Digital Twin at GarudaUAV

GarudaUAV utilises precise aerial, mobile, terrestrial and 360-degree panoramic LiDAR and Photogrammetry data collection and integration to fulfil customised project objectives. This data can be further visualised and analysed on our proprietary digital platform, BlueHawk. In projects requiring scalable models, a Building Information Model (BIM) or a 3D Vector Model is used. However, these models require additional manual inputs and may appear ‘abstract’

In contrast, 3D Texture Models enhance the realism of data by capturing intricate surface details and colour, particularly in urban environments (Figure 1). The Level of Detail (LoD) varies depending on the project, with higher LoDs necessitating greater data overlap, which in turn increases project costs. However, these models

Figure 1: 3D Texture Model illustrating an urban landscape in India, capturing infrastructure elements like roads, buildings, and parks etc. in detail. Source: GarudaUAV.

significantly improve visual representation and facilitate better communication between technical and non-technical stakeholders.

To illustrate the practical applications of Digital Twins, GarudaUAV employs several use cases and offer Digital Twin models up to LoD 4. These use cases include:

Use Case 1: Accurate Building Facade Measurement and 3D Modelling

The measurements of building facades, including window and door dimensions, roof angles, and wall textures can be accurately extracted (Figure 2(a)). This also enables the creation of precise 3D models (Figure 2(b)). Additionally, Artificial Intelligence and Machine Learning techniques streamline processes like image segmentation and object classification, minimizing reliance on manual interpretation and digitization

Use Case 2: Enhancing Design Visualization through Data Integration

The integration of 3D Texture Model with BIM and/or 3D Vector Model create a highly realistic visualization of various project components. This integration enables precise modelling of streetlights, including their height and placement (Figure 3). By equipping these streetlights with IoT sensors, performance monitoring can be enhanced while expanding the urban analytics capabilities.

Figure 2: (a) Height and length data of a building extracted from a 3D texture model, allowing for enhanced visualization of spatial relationships and scale; (b) The buildings (in red) and trees (in blue) are digitized to create a 3D vector model from the 3D texture model.

Integrating a complex vector model like BIM with a 3D Texture Model allows urban planners, architects and designers to showcase intricate details such as materials, colours, and lighting effects (Figure 4). This realism enables informed design decisions and facilitate real-time data integration to keep land records updated throughout the project lifecycle. The use cases provided above, offer just a glimpse into potential of 3D Texture Model for Digital Twins in urban planning. In a nutshell, these benefits are categorized as:

Enhanced Realism: Lifelike visualisation for urban changes and planning..

Spatial Analysis: Assessments of land use, traffic patterns, and environmental impacts.

Data Integration: Real-time IoT data for dynamic updates and management.

Risk Assessment: Identifies and mitigates risks through scenario visualization.

Figure 4: BIM model of a house integrated with 3D texture data, showcasing a realistic visualization of the final appearance. The attribute table highlights the land record information that can be digitally stored and regularly updated through real-time data integration.

Figure 3: Vector models of streetlights integrated into the 3D texture model to demonstrate the potential final appearance of the infrastructure. The attribute table highlights potential data that could be collected from IoT devices on these streetlights. Source: GarudaUAV.

Public Engagement: Communicates complex ideas effectively, fostering public feedback on developments.

Lessons Drawn from Digital Twins

Digital Twin technology is increasingly adopted by cities worldwide to improve urban planning, management, and citizen engagement. Notable examples include Singapore's comprehensive city planning, Barcelona's Sentilo Platform and Amsterdam's City Data platform. Countries like South Korea and the United Arab Emirates (UAE) have also demonstrated successful case studies offering valuable lessons and continuous improvement. However, one of the key challenges in implementing digital twins is ensuring data quality and seamless integration. Balancing scalability with performance is also critical, along with managing finances and resources. Additionally, navigating regulatory and policy frameworks to maintain compliance adds further complexity.

Conclusion

Digital twins are transforming urban infrastructure and enhancing residents' quality of life. However, challenges persist. It is essential to clearly define project objectives and data requirements before launching any digital twin initiative. Different projects demand varying levels of detail, and not all initiatives require highly precise data. However, it is undeniable that the future will see widespread adoption of digital twin applications. Early adopters will be better positioned to capitalize on its advantages and maintain a strategic edge.

Article: Avineon India

3D Digital Twin to Support Strategies for Building Renovation and Climate Action Plans

Digital Twin technology plays an increasingly important role in modeling, monitoring, analyzing, and simulating complex “what-if” scenarios and policy options for the built environment. At times of increasing energy prices and global climate urgency, there is a high need for decision support systems to assess strategies for the reduction of the building energy demand and the associated CO2 emissions, both at the individual level and the district or city level.

Digital Twin is designed as a virtual representation of the building stock, established through accurate 3D modeling, and enriched with additional geometry representing windows, chimneys, and solar panels in addition to attributes relating to the energy efficiency of the buildings.

Creation of 3D Building Models

Using high-resolution stereo aerial imagery, precise and detailed 3D models for the building stock, compliant with CityGML standard LOD2.3 are developed. This 3D city model forms the core of the Digital Twin platform.

The detailed 3D models of the individual buildings are further enriched with roof windows, chimneys, and existing solar panels, all derived through AI and object detection algorithms, and further adjusted manually for accuracy. When oblique imagery is available, these detection algorithms are extended and provide information on facade windows and doors as well.

As a next step, the highly detailed 3D model can be coupled with an energy simulation model like VITO (called EBECS), which allows building heating demand, energy efficiency, and renovation costs to be associated with the buildings.

Data communication between these Digital Twin components is based on Energy Application Domain Extension (Energy ADE) for CityGML, assuring a standardized data model for energy-relevant information together with the 3D city model. The enriched city model is stored in an industry-standard database for 3D city models, called 3DCityDB.

Fig 1: 3D Representation of Buildings embedded with energy efficiency attributes

Digital Twin Environment

The Digital Twin infrastructure includes a powerful Web App that provides a highly performant interface for fast 3D visualization, querying, and analysis of the enriched 3D building data.

All the building information is disclosed via an OGC-compliant GIS platform that, on one hand, allows the analysis of the renovation potential of the buildings and, on the other hand, allows the production of custom reports for different stakeholders, all to increase the renovations in the residential housing market.

The capabilities/functionalities of the platform can include:

- The storage of enriched 3D building models compliant with the CityGML exchange standard and its Energy Application Domain Extension
- The possibility to enrich the buildings further with custom attributes
- The connection to building energy modeling tools and energy consumption databases
- The visualization of the buildings’ geometry and properties in a 3D viewer, including the various scenarios that are calculated to achieve specific goals in energy efficiency or budget

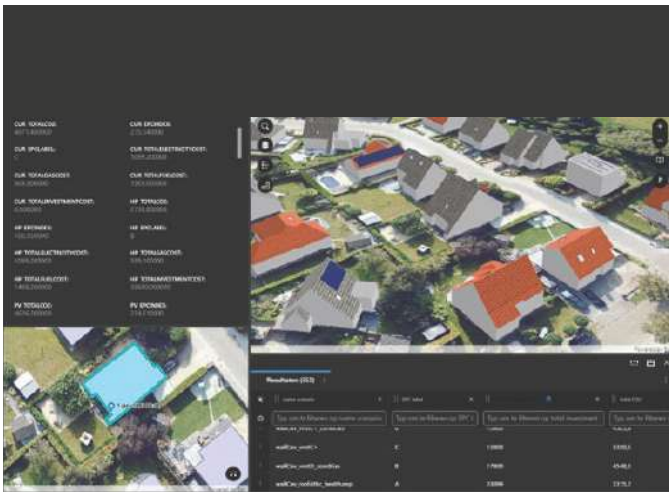


Figure 2: 3D Buildings integrated with an energy simulation model to assess building energy efficiency and renovation costs

- The creation of summary graphs and reports about buildings' characteristics, either individually or aggregated on the street segment, building stock, neighborhood, or city level
- The user-specific and GDPR-compliant data access and visualization using a multi-tenant infrastructure.
- The update of building characteristics by end users (e.g. homeowners)

By bringing together the detailed 3D City Models and high-performance Digital Twin environment with the energy simulation models, a new platform is created that allows for the simulation, analysis, and visualization of building renovation strategies and assess the impact of

crucial questions like:

- What is the most cost-effective way to reach a specific Building Energy efficiency label?
- How much overall efficiency is achievable for several buildings, given a fixed budget?
- How can I optimize my renovation budget for a given set of buildings?

  How can I track the renovation status or energy efficiency improvement for a given building stock or area?
- What common renovation measures have the biggest impact when promoted on a city/district level?
- How do renovation strategies translate into reduced CO2 emissions?

Conclusion

With experience modeling over 1 million buildings across 30+ cities in Asia, Europe, and North America regions, Avineon provides out-of-the-box & customized 3D City Web Portals and Digital Twin environments for visualization and analysis and is a one-stop provider for all 3D services.

With experience modeling over 1 million buildings across 30+ cities in Asia, Europe, and North America regions, Avineon provides out-of-the-box & customized 3D City Web Portals and Digital Twin environments for visualization and analysis and is a one-stop provider for

Figure 3: Tools for building renovation, energy demand, and CO2 reduction analysis on the Digital Twin Platform

climate action plans. This pushes what we can get out of the energy simulation models to achieve the next level of accuracy in estimating the heating demand of buildings and in quantifying the renovation scenarios in terms of return on investment or potential energy and CO2 emission reduction.

This Digital Twin concept facilitates informed decision-making for different stakeholders (cities, social housing companies, homeowners, etc.), providing answers to all 3D services. The use of detailed 3D building models, enriched with additional geometry, and relevant attributes, and imported in a high-performance environment, offers a promising approach to address the renovation of many buildings in an informed way. This approach not only reduces the costs of the building inventory, but also optimizes the choice of which buildings and which renovation techniques to use, providing insight into the required budgets, and offering possibilities to monitor the renovation.

Article: Asteria Aerospace

How Drones are Powering Digital Transformation in Telecom Operations?

New 5G rollouts, more diverse network technologies, the emergence of new business models and other market trends require telecom companies to be more agile, data-driven, and focused on increasing their operational bottom lines as well as pursuing new revenue streams. As companies across industries have discovered, the best catalyst to achieve these outcomes is digital transformation, with drones playing a crucial role.

Drones equipped with advanced cameras and sensors along with end-to-end drone data management software provide telecom companies with accurate, real-time data, enabling them to manage infrastructure more efficiently and safely. This blog explores the role of drones in telecom, the key trends driving their adoption, and how they are helping companies achieve operational excellence.

Why Telecom Companies Need Digital Transformation

Several factors are driving telecom companies to embrace digital transformation and adopt modern technologies like drones:

5G Rollouts: The rollout of 5G networks has introduced more complex network architectures, increasing the frequency and speed of upgrades. Telecom companies need real-time visibility into the quality of their network assets to ensure smooth operations and effective network management.

Market Pressures: Telecom leaders are seeking new revenue streams, such as leasing available space on existing tower assets. To make these business models work, companies must have a continuous view of asset quality and availability.

Operational Efficiency: With increasing pressure to improve efficiency, telecom companies are focusing on optimizing operations and maintenance workflows. Digitizing maintenance records and having real-time site data can lead to significant cost and time savings.

Shortage of Skilled Personnel: Traditional data collection methods at tower sites often involve risks, manual workflows, and a need for skilled personnel, who are in short supply. Drones help overcome these challenges by automating inspections and reducing the need for manual labor.

Drones: A Key Tool for Digital Transformation

Drones have become indispensable tools for telecom companies, offering a range of benefits that enhance operations, safety, and data collection.

Here are some of the primary advantages of using drones for telecom tower management:

Autonomous Surveys and Data Collection

Drones can autonomously survey telecom towers within minutes, capturing high-resolution images and data. These drones can be equipped with sensors to create a digital twin of the site, providing real-time data on tower conditions.

360-Degree Image Coverage

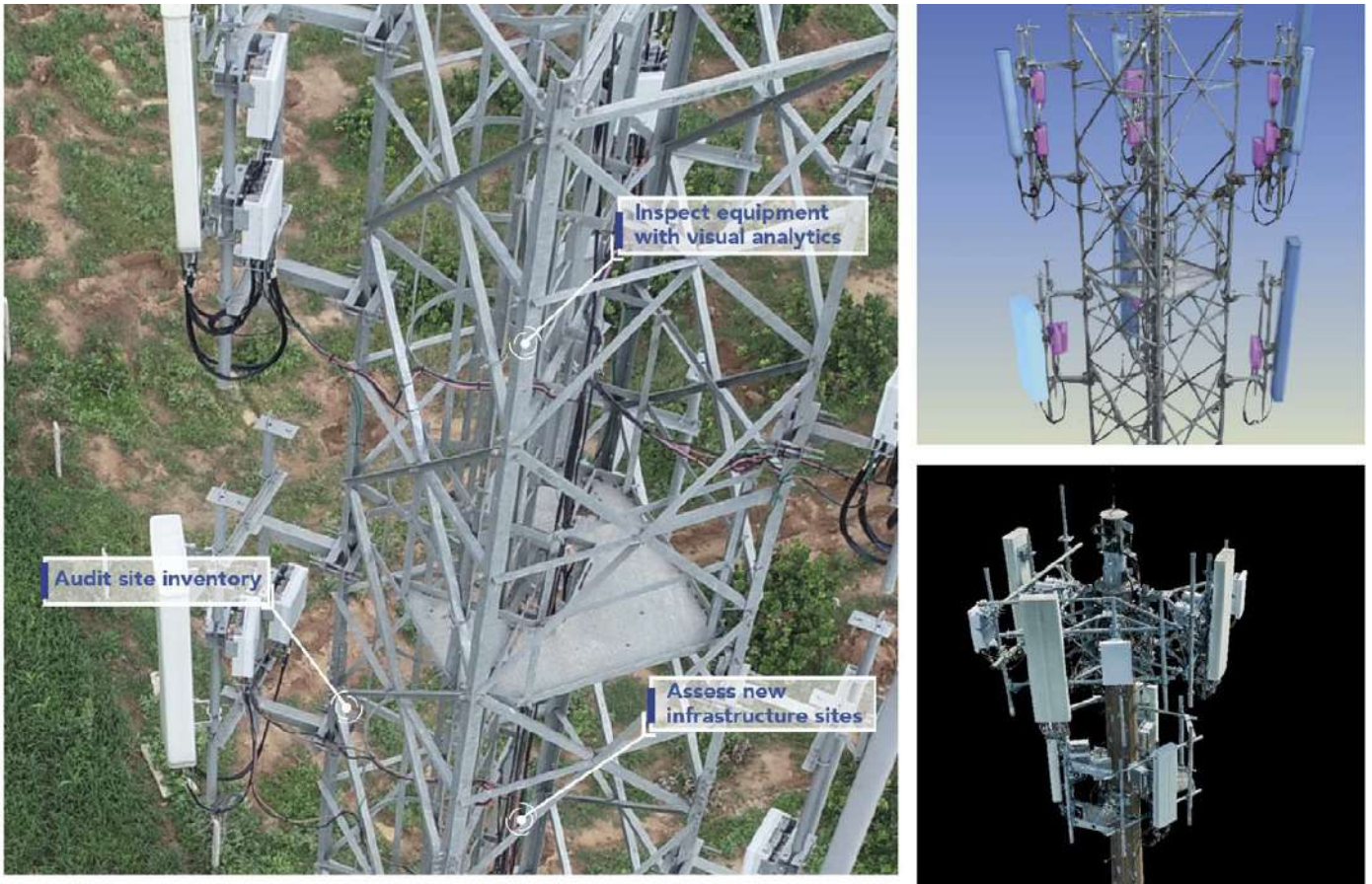
Drones offer complete 360-degree image coverage of towers, ensuring that every angle is captured for accurate analysis. This comprehensive visibility is crucial for maintenance planning, ensuring that no potential issue goes unnoticed.

Fast Time Decision Making with Digital Twin

The data collected by drones can be processed in real-time, allowing telecom companies to create a digital twin of their infrastructure. This virtual model provides a comprehensive view of tower conditions, enabling companies to make timely, data-driven decisions. Whether it's upgrading a tower or addressing maintenance issues, having accurate digital twin data at your fingertips is essential for operational efficiency and proactive management.

Easy Access to Remote Towers

Telecom towers are often located in remote or hard-to-reach areas. Drones can easily access these sites, conducting inspections that would otherwise require heavy equipment or significant travel time. This ease of access reduces the operational burden on telecom companies.



Drones flying orbital flight paths to capture high resolution imagery, and 3D digitization

Improved Safety

By replacing traditional inspection methods, which often require workers to climb towers, drones enhance staff safety. Inspections are carried out from the ground, minimizing the risk of accidents.

Enhanced Revenue Opportunities

Telecom companies can leverage drones to assess the condition of available tower space for lease, maximizing the use of their infrastructure. Drones provide precise measurements and data on space availability, which is essential for supporting new business models, such as renting out tower space to third parties.

Cost and Time Savings

Manual inspections are labor-intensive and time-consuming. Drones reduce the need for these inspections, resulting in significant cost and time savings. Additionally, the real-time data collected by drones accelerates decision-making, reducing project timelines.

SkyDeck: Enhancing Drone Operations for Telecom Companies

A crucial element in leveraging drones for telecom operations is the ability to manage, process, and analyze the data they capture. Asteria Aerospace's SkyDeck platform simplifies this process by offering an integrated solution for drone data management. SkyDeck's cloud-based platform allows telecom companies to automate mission planning, process high-resolution imagery, and generate actionable insights in real-time.

Additionally, SkyDeck enables the creation of **highly accurate digital twins** of telecom towers, providing a virtual model that reflects real-time conditions of the infrastructure. This digital twin allows for detailed assessments, remote inspections, and predictive maintenance, making asset management more efficient and reliable. By using SkyDeck, telecom companies can optimize drone operations, enabling faster decision-making and improved asset management.

Drones have become essential tools for telecom companies, enabling them to increase operational efficiency, improve safety, and enhance decision-making. With real-time data collection, technology provides telecom companies with a detailed, accurate view of their infrastructure, enabling digital transformation and the creation of **digital twins** for better asset management.

Sign up for a free trial of SkyDeck today.

Article: JSAN Consulting

3D Digital Twin to Support Strategies for Building Renovation and Climate Action Plans

In an era driven by data, innovation, and interconnected systems, the concept of Digital Twins has emerged as a transformative force across industries. No longer futuristic, Digital Twins is now a practical technology that allow organizations to simulate, monitor, and optimize systems in real time. From manufacturing and healthcare to urban planning and infrastructure, Digital Twins are driving efficiency, productivity, and innovation.

The integration of real-time data, artificial intelligence, and cloud computing has elevated Digital Twins from static simulations to dynamic, real-time systems capable of enabling data-driven decisions through advanced analysis and implementation.

Digital Twins are revolutionizing industries by providing simulation, optimization, and predictive insights. For example, manufacturers reduce equipment downtime, healthcare professionals deliver personalized treatments through organ simulations, energy providers ensure reliability with predictive maintenance, aerospace industries conduct virtual testing, and logistics companies optimize supply chains.

Urban planning is a notable application of Digital Twin technology. Planners use Digital Twins to model cities and infrastructure, enabling them to optimize traffic flow, reduce energy consumption, and enhance city services. A Digital Twin of a city can simulate scenarios such as natural disasters, population growth, and resource allocation to ensure sustainable urban development.

Use Cases: Traffic Management with Digital Twins

Two prominent examples highlight the use of Digital Twin technology in addressing specific challenges related to road traffic.

1. Optimizing Traffic Signal Timings

The first example is optimizing traffic signal timings based on real-time situations, as illustrated by Dasgupta et al. (2021, arXiv:2109.10863). By creating a virtual replica of traffic signal systems, vehicles, and road networks, this solution ensures accurate decision-making for traffic management. The system seamlessly transmits vehicle trajectories and traffic signal data from physical systems to the Digital Twin, which processes the information to make precise signal timing adjustments.

Unlike traditional Adaptive Traffic Signal Control (ATSC), which struggles to address congestion, this system dynamically prioritizes green light phases based on the Average Waiting Time (AWT) of vehicles at intersections and upstream signals. The Digital Twin solution effectively distributes waiting times across the network, significantly enhancing user travel experiences in congested areas. By leveraging real-time data and optimizing signal phasing dynamically, it minimizes delays and ensures smoother traffic flow, even in saturated conditions.

This approch is highly adaptable and can be scaled up to manage city-wide traffic systems, to address broader congestion challenges. It demonstrates how Digital Twins can solve highly specific urban mobility problems, transforming traffic management for improved efficiency and user satisfaction.

2. Traffic Flow Model for Highways

The traffic flow Digital Twin model for highways, developed by Li and Zhang (DOI: 10.1038/s41598-023-27696-z), uses radar-camera sensor fusion to create dynamic, scalable traffic models. By integrating radar's all-weather speed and distance accuracy with the camera's detection precision, the system provides reliable traffic information even in low light and adverse weather conditions.

In this end-to-end implementation, radar-camera pairs deployed at roadside sites track vehicles in real time. Data is integrated into a unified coordinate system to build a dynamic traffic flow model. A novel automatic sensor calibration

method aligns radar and camera data using highway road features, eliminating the need for additional equipment. A Kalman filter-based framework further enhances precision by minimizing errors and improving target tracking.

This approach dynamically allocates green phases based on cumulative waiting times, optimizing traffic signal control and reducing delays across the network. The fusion of radar and camera data ensures highly accurate, real-time traffic flow information, for the purpose of optimized traffic signals, and intelligent transportation systems.

This demonstrates the potential of Digital Twin technology to solve specific traffic challenges, that improve urban mobility and transportation infrastructure.

Challenges Implementing Digital Twin Technology in India

1. Limited Scope of Current Digital Twins

The existing Digital Twins are largely limited to 3D visual representations of the real world and fail to reflect real-time traffic system dynamics accurately. To address this, integrating real-time sensor data such as radar, cameras, and IoT systems, along with AI and machine learning algorithms, will enable Digital Twins to become dynamic, predictive, and adaptive tools capable of handling real-world complexities.

2. Difficulty in Synchronizing Real and Virtual Data

Synchronizing the physical traffic system with its virtual counterpart is a major challenge due to sensor inaccuracies, latency issues, and data transmission delays. Implementing robust sensor calibration frameworks, such as radar-camera fusion with unified coordinate systems, and leveraging low-latency 5G networks can resolve these synchronization issues and ensure real-time updates between systems.

3. Infrastructure and Data Collection Challenges

India's diverse road infrastructure, heavy traffic density, and inconsistent roadside sensor deployment create significant challenges for reliable data collection.

Deploying radar-camera sensor fusion systems across urban corridors can ensure accurate and all-weather data collection, while government-backed funding and standardization initiatives can help address infrastructure gaps.

4. Scalability Across Urban and Rural Networks

Scaling Digital Twin solutions beyond urban areas to India's vast rural and highway networks remains a challenge due to infrastructure and resource limitations. A phased approach starting with pilot programs in metro cities can provide a foundation for scaling up to national highways and tier-2 cities using modular and scalable frameworks tailored to India's needs.

5. Cost and Resource Constraints

The high costs associated with sensors, IoT infrastructure, and computing resources pose a significant barrier to implementing Digital Twin technology in India. Promoting public-private partnerships can help share costs and expertise, while adopting cloud-based Digital Twin platforms can reduce infrastructure expenses and make the solution more scalable.

6. Public Awareness and Adoption

A lack of awareness and understanding among stakeholders and the public can hinder the success of Digital Twin solutions. Conducting awareness campaigns for traffic authorities, urban planners, and citizens, while showcasing tangible benefits like reduced congestion and improved travel times, will encourage widespread adoption and support.

Conclusion

The successful implementation of Digital Twin technology in India depends on addressing key challenges such as synchronization issues, infrastructure gaps, costs, and privacy concerns. By leveraging advanced sensor fusion, AI, and scalable frameworks, Digital Twins can revolutionize traffic flow management, creating smarter and more efficient urban mobility solutions tailored for India's diverse needs.

Startup Showcase: Kesowa

Demystifying Digital Twins: Harnessing Real-Time Data for Smarter Urban Development

In the evolving landscape of urban planning, Digital Twins have emerged as a game-changing technology. A Digital Twin is a virtual replica of a physical asset, environment, or system that continuously updates through real-time data. By harnessing the power of IoT, AI, and advanced data analytics, Digital Twins allow city planners, developers, and others to monitor, simulate, and predict the future of urban spaces. Initially conceived for product lifecycle management in industries like manufacturing and aerospace, the application of Digital Twins has expanded into urban development, where they can optimize everything from traffic management to infrastructure maintenance. This integration offers cities the ability to evolve in a more efficient, transparent, and sustainable manner.

Digital Twins for Different Users

While the concept of Digital Twins is transformative, its utility differs depending on the user. By understanding the needs of diverse stakeholders, we can see the ways in which Digital Twins enhance urban spaces:

City Planners

City planners use Digital Twins to model various urban development scenarios, such as new infrastructure projects, zoning changes, or environmental impacts. Real-time data allows them to monitor the current state of public utilities, transportation, and environmental conditions, making planning proactive rather than reactive.

Developers and Construction Firms

Developers benefit immensely from the insights provided by Digital Twins. These virtual models can track construction progress, ensure regulatory compliance, and reduce project delays. Developers can also use predictive modeling to foresee potential issues, optimize resource allocation, and stay ahead of project timelines.

Government & Civic Authorities

For civic authorities, Digital Twins provide a central platform for managing the day-to-day operations of a city. A Digital Twin allows for real-time insights and timely interventions.

Citizens

Citizens can visualize ongoing projects in their neighborhood, track changes to public spaces, and even provide feedback on city plans. This fosters community engagement and ensures urban development aligns with residents' needs.

CAI and VPI: Indicators of Urban Growth and Livability

One of the key advantages of Digital Twins is their ability to measure and analyze urban growth through specific AI-generated indices like the CAI and VPI. These metrics, derived from high-resolution drone-based mapping data, provide real-time insights into the livability and developmental pace of city blocks.

Construction Activity Index (CAI): This index measures the intensity of construction activity in an area. A low CAI indicates little to no development, whereas a high CAI suggests rapid infrastructure growth, which may come with associated challenges like congestion or strain on local resources.

CAI

- 0-25 : Very Low Activity (Dormant Zone)
- 25-100 : Low Activity (Mild Hustle)
- 100-200 : Moderate Activity (Steady Surge)
- 200-400 : High Activity (Active Ambition)
- 400-1000 : Very High Activity (Dynamic Development)

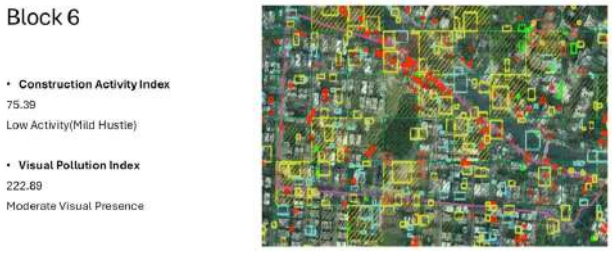
Visual Pollution Index (VPI): The VPI measures the visual impact of urban development, taking into account factors like construction debris, road damage, and other disturbances to the visual landscape. Higher VPI scores represent greater visual disturbance, which can negatively impact residents' quality of life.

VPI

- 0-50 : Minimal Visual Impact
- 50-150 : Subtle Visual Influence
- 150-250 : Moderate Visual Presence
- 250-350 : Significant Visual Impact
- 350-1000 : High Visual Disturbance

Example

In a recent analysis of several residential blocks in a Tier 2 City, we observed significant variation between these indices. For example, Block 6 recorded a CAI of 75.39, indicating steady construction activity, paired with a VPI of 222.89, reflecting considerable visual disturbance. Conversely, Block 5 had a lower CAI of 23.27, signaling minimal construction, yet its VPI of 152.26 still suggested moderate visual disruption.



These insights are crucial for city planners and civic authorities to balance urban growth with livability. High CAI and VPI scores often indicate areas that need intervention, such as beautification projects or stricter construction guidelines, to mitigate negative impacts on the urban environment.

Monetizing Data and Creating a Feedback Loop

The power of Digital Twins extends beyond urban management to creating new revenue streams through data monetization. Cities that invest in Digital Twins can leverage the data generated for commercial use, creating a self-sustaining ecosystem of continuous improvement. Using the Drone Data Monetization Plan developed for a City, we explore several use cases for monetizing data collected through Digital Twins:

Reports for Residential and Commercial Plots:

Drone and GIS data can be packaged into detailed plot reports, providing valuable information for plot owners and developers. These reports include orthomosaic maps, change detection over time, and even tree counts, allowing property owners to make data-driven decisions about land use and development.

Monetization Opportunity: Each plot report could be sold for a fixed fee, generating substantial revenue for the city.

High-Resolution GIS Map Resale:

The city's high-resolution drone data can be resold to GIS companies, startups, and mobility platforms. This data can be used to improve navigation systems, create training datasets for AI models, or even develop local tourism applications.

Monetization Opportunity: GIS map resale can generate revenue while fostering innovation by making detailed, high-quality data available to private companies.

Block Intelligence Reports:

For local businesses and banks, Digital Twins offers intelligence reports on various city blocks, including consumer footfall, construction status, and environmental quality. These insights allow businesses to make strategic decisions about location and expansion.

Monetization Opportunity: Block intelligence reports can be sold as subscription services to local businesses, contributing to the city's revenue stream.

The Feedback Loop: Driving Continuous Improvement

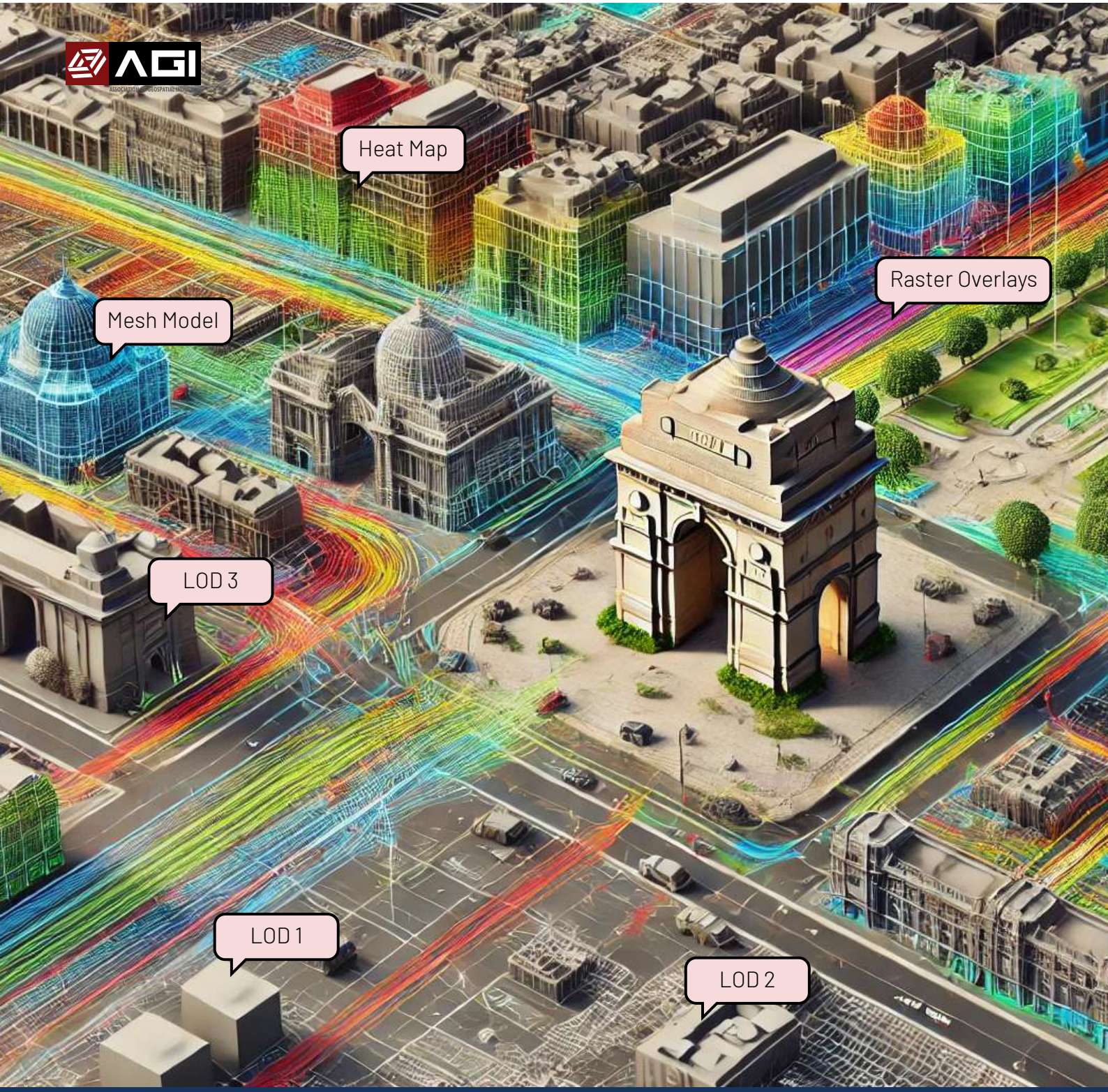
As more data is collected through drones and Digital Twins, cities can create a continuous feedback loop. This iterative process enables smarter urban planning, as each layer of data informs the next, improving the accuracy and relevance of the Digital Twin. This concept can be metaphorically linked to Moore's Law, where iterative improvements in technology lead to exponential advancements over time.

Each new dataset enhances the city's ability to predict and respond to future challenges. For example, recurring high VPI scores in specific blocks may prompt city planners to invest in green spaces or underground utilities, thus reducing the visual impact of future construction.

Cities can superimpose infrastructure spending and allocation budgets on Digital Twins to assess impact and value enhanced per citizen in a specific Area of Effect. Over time, predictive capabilities of Digital Twin grow stronger, making cities more adaptable, resilient, and sustainable.

Conclusion

Digital Twins have the potential to revolutionize urban development by offering real-time data, actionable insights, and a continuous feedback loop for improvement. As cities demonstrate, integrating drone technology and leveraging data monetization can not only enhance urban planning but also create new revenue streams. By embracing Digital Twins, cities can become smarter, more efficient, and more livable for future generations.



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