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GIS For AEC

COVER STORY

Building Smarter Infrastructure with GIS

CASE STUDY

Revolutionizing Irrigation Pipeline Design using ArcGIS

ARTICLE

GIS-powered Digital Twins – Transforming Operations & Decision-Making

PRODUCT REVIEW

ArcGIS GeoBIM

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Plot no. 8, Elegance Tower, 5th Floor,
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New Delhi - 110025, Delhi

BENGALURU
IndiQube Gradeur 14, Walton Rd,
Shanthala Nagar, Ashok Nagar,
Bengaluru - 560001, Karnataka

HYDERABAD
Apeejay Business Center, Tresorie,
1st Floor, The PARK, 22, Raj bhavan Road,
Hyderabad - 500082, Telangana

KOLKATA
Urbanwrk Private Limited, 8th Floor, Technopolis
Building, BP Block, Sector V, Bidhannagar,
Kolkata - 700091, West Bengal

MUMBAI
AWFIS Space Solutions Private Limited,
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TABLE OF CONTENTS

Agendra Kumar
Managing Director, Esri India

Infrastructure development plays a pivotal role in driving economic progress and shaping a country's future development possibilities. India's vision to achieve a $40 trillion economy by 2047 involves not only strengthening the physical infrastructure of the country but also the digital and social infrastructure.

Accordingly, the Government is undertaking ambitious projects, such as the Delhi-Mumbai Expressway, Central Vista, and Chenab Railway Bridge, showcasing the potential for innovative and sustainable infrastructure. The National Infrastructure Pipeline (NIP), which was launched with 6,835 projects and has expanded to capture over 9,288 projects with a total outlay of INR 108.88 trillion between 2020-25, emphasizes social and infrastructure projects in energy, roads, railways, and urban development. The PM Gati Shakti Master Plan complements NIP, focusing on improving India's logistics network.

The India Infrastructure Report 2023 on Urban Planning and Development, reiterates the Government of India's commitment to higher investments in the infrastructure sector, with a particular focus on prioritizing railways, roads, aviation, ports, industrial and urban development, especially in tier-2 and tier-3 cities. The Interim Budget 2024 has indicated that capex outlay allocation will be increased by 11.1% to INR 11,11,111 lakh Crore, accounting for 3.4 % of GDP. This will unlock the potential for infrastructure development in the country as a major part of this allocation will be used for various infrastructure upgrades and new projects.

The Government's inclination to strengthen the country's infrastructure is evident and to accomplish the lavish infrastructure development goals, it is crucial to make the efforts digitally enabled. Technology adoption is a very important ingredient of this success story, and encouragingly, the AEC sector is ramping up its digital transformation efforts to make strides in this dynamically changing scenario of India's growth.

The sector is breaking out of silos and using technologies like sensors, image capture, advanced 3D visualization, GIS, and BIM to create an intelligent nervous system for our infrastructure. This integrated web of technology is changing how the AEC industry is working and making decisions. The shift towards continuous, real-time information, powered by technologies like Esri's ArcGIS system is empowering the stakeholders to understand what actions to take, when, and where. GIS is fostering a culture of transparent communication and collaboration as information flows seamlessly among multiple stakeholders through the system.

AEC firms are also exploring the idea of Digital Twins to achieve higher efficiencies in their projects. The combination of GIS with BIM, which has been around for a while, is enabling digital twins. The integration allows the digital representations of projects to be connected to the physical project itself. As GIS-based systems evolve to accurately analyze 3D maps, AEC firms stand to gain more impactful insights that can help them achieve significant time and cost savings.

There has never been a more urgent need to create resilient and sustainable infrastructure. GIS plays a pivotal role in the creation of sustainable infrastructure by providing a comprehensive and spatially aware approach to planning, development, and management. GIS enables the assessment of the environmental impact of infrastructure projects by analyzing factors such as terrain, ecosystems, and biodiversity. This information aids in designing projects that have minimal negative effects on the environment.

Overall, GIS has become a valuable tool for infrastructure development, helping governments and organizations make informed decisions and optimize resources. As the AEC industry matures, we will see higher adoption of the latest technologies in the processes, and this is where technologies like GeoAI will make a difference.

GIS Day 2023- Celebrate & Win Contest Winners Announced

In October, Esri India rolled out the 2023 Esri India GIS Day- Celebrate & Win Contest to encourage organizations to celebrate GIS Day. The event aimed at fostering enthusiasm for GIS amongst the user community. Over 80 unique organizations actively participated in the event, showcasing that the utilization of GIS technology is on a significant upswing across diverse industries. The participants hailed from diverse sectors including NGOs, educational institutions, as well as private and public organizations.

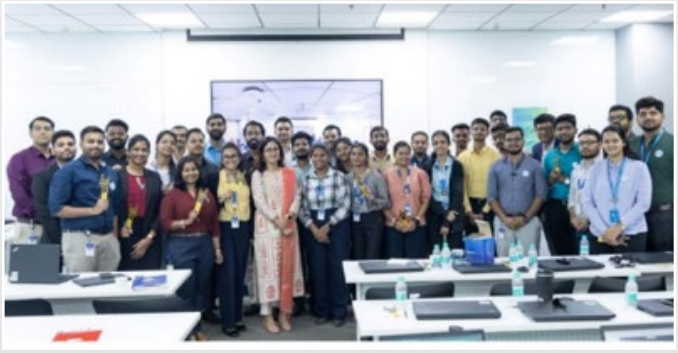
The event concluded in January with the announcement of the top 4 winners

1. Assam State Disaster Management Authority, Guwahati
2. Centre for Applied Geomatics, CEPT Research and Development Foundation, Ahmedabad
3. Geographical Society of Central Himalaya, Dehradun
4. Burns & McDonnell India, Mumbai (Special Recognition)

Assam State Disaster Management Authority, Guwahati

Center for Applied Geomatics, CEPT Research and Development Foundation, Ahmedabad

Geographical Society of Central Himalaya, Dehradun



Burns & McDonnell India, Mumbai (Special Recognition)

44 Students Visit ISRO facility as part of MMGEIS Program

44 students from eight cities visited the ISRO Telemetry Tracking and Command Network (ISTRAC) centre as part of the recently launched Master Mentors Geo-Enabling Indian Scholars (MMGEIS) Program, a joint initiative by Centre of Knowledge Sovereignty and Esri India. It marks as a notable milestone in our commitment to inspiring the next generation of geospatial thinkers.

The visit of students to ISTRAC centre exposed students to real-world applications of geospatial technology and acted as an impetus to inspire them to explore the vast possibilities within the field. During the visit, students were exposed to various aspects of ISRO's ground-breaking work, including control centre, and space applications. During the visit, the students engaged in interactive sessions with Shri A.S. Kiran Kumar, Member, Space Commission and former chairman of the Indian Space Research Organisation (ISRO). They got an opportunity to witness firsthand the critical role geospatial technology plays in various space exploration and Earth observation projects. The experience provided them with a rare glimpse into the practical applications of the technology and ignited a spark of curiosity and aspiration among the students, many of whom expressed their newfound interest in pursuing careers in space science and technology.

Shri Vinit Goenka, Secretary, Centre for Knowledge Sovereignty sharing his observations on the visit said, "We launched MMGEIS as we understood the importance of good mentors in our lives. Geospatial technology is increasingly vital in our rapidly advancing world. The visit to ISRO was a pivotal moment for these students, allowing them to connect their classroom learning with real-world applications and inspiring them to dream big."

"MMGEIS aims to foster a passion for geospatial technology and equip them with skills that will enable them to focus on innovation," he added.

Shri Agendra Kumar, Managing Director, Esri India highlighted, "This visit to ISRO was a revelation for our students. It not only enlightened them about India's advancements in space technology but also encouraged them to dream big and contribute to our nation's space endeavours."

Esri India wins the Best B2B Brand of the Year Award

B2B World Summit & Awards is India's largest B2B conference where thought leaders from across the APAC region share their innovative strategies for converting marketing teams into avenues of revenue. The B2B Awards, which are presented at the conference, recognize great work done in the field of marketing. The conference helps the entire community to grow together as attendees learn from best-in-class case studies from their peers.

The B2B Marketing Awards winners for the year 2023 were declared on 22nd November during a Virtual Awards Ceremony. Esri India received the 'Best B2B Brand of the Year Award' for the year. It was a proud moment for our branding and marketing efforts to get recognized on a wide platform amongst the leading thought leaders and innovators from the B2B World.

Esri India Customers Bag Prestigious Geospatial Awards

The AGI Secretariat organized the India Geospatial Leadership Summit on 20th February 2024 at the India International Centre, New Delhi.

During the Summit, **AGI India Awards 2024** were awarded to the industry, users, and research organizations doing exemplary work with geospatial technologies. The projects were weighed on various parameters, including the size of the project, innovative use of geospatial Technologies, the impact of the project, and its outcomes.

Competing among various central and state government agencies, the geospatial private sector, and academia, two of Esri India's coveted customers, **Maharashtra Remote Sensing Applications Centre (MRSAC) and Municipal Corporation of Delhi (MCD)**, bagged the prestigious award. MRSAC's MahaBHUMI Geo-Portal and MCD's GIS Citizen Portal gained this recognition for ensuring better governance and improved citizen-centric services at varied levels.

Building Smarter Infrastructure with GIS

There is a dire need to strengthen India's infrastructure. As the world's second most populous country, India houses more than 1.4 billion people currently, and the numbers are continually growing. It is also one of the fastest-growing economies in the world, with an annual growth rate of 7.2%. Improved infrastructure is required not only to accommodate the rising population but also to keep pace with the rapid economic growth. The Indian government has estimated that the country needs to invest US$1.4 trillion in infrastructure by 2025 to achieve the $5 trillion economy vision. As per a report by KPMG, India is the fastest-growing construction market, currently clocking around 7-8% annual growth. By 2025, India is poised to overtake Japan.

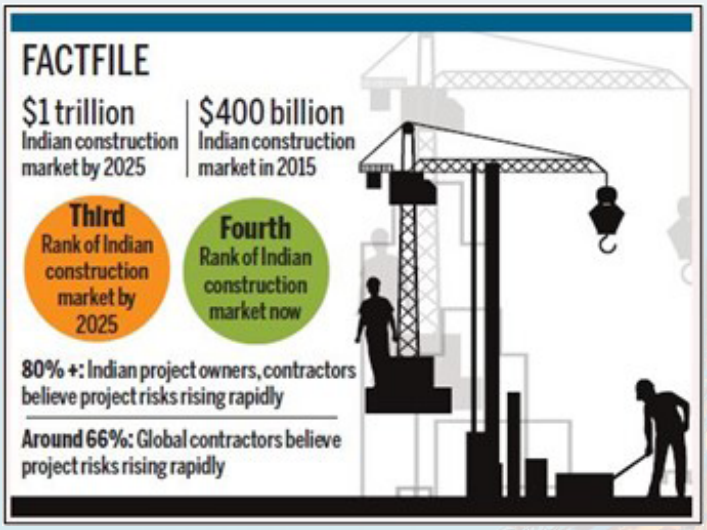
Rising Challenges

With the growing size and quantum of projects in AEC, the complexities and associated risks are also increasing. Infrastructure projects are not just capital intensive with 30% wastage, 40% rework, and significant schedule overruns, the industry also accounts for 39% of energy consumption and is responsible for 19% of GHG emissions.

Landscape, access, utilities, amenities, natural resources, and their impact on the local environment and ecology are integral aspects to consider. Moreover, as a disaster-prone nation, disaster risk to projects due to natural hazards is considerably high.

Additionally, factors like regulatory issues, weather conditions, unforeseen site conditions, or disputes often lead to project delays. These delays often lead to cost overruns and can strain relationships between stakeholders. Budget overruns are a significant concern in the AEC industry. Unforeseen expenses, changes in project scope, or inaccurate initial cost estimates can lead to financial challenges for contractors and developers. The industry also often faces shortages of skilled labor, including architects, engineers, and construction workers. This can lead to increased competition for talent and potential compromises in project quality. Also, with sustainable practices and green building standards becoming the need of the hour, higher upfront costs need to be considered. All these factors can have an impact on project delivery, profitability, and overall sustainability of infrastructure projects.

Addressing these challenges often involves a combination of industry collaboration, **technological innovation**, effective project management, and a proactive approach to risk management. By embracing digital transformation, the AEC industry stands to benefit in almost every aspect of the project lifecycle. From improved project management to enhanced collaboration and streamlined design and construction, the impact of digital transformation is far-reaching and transformative.



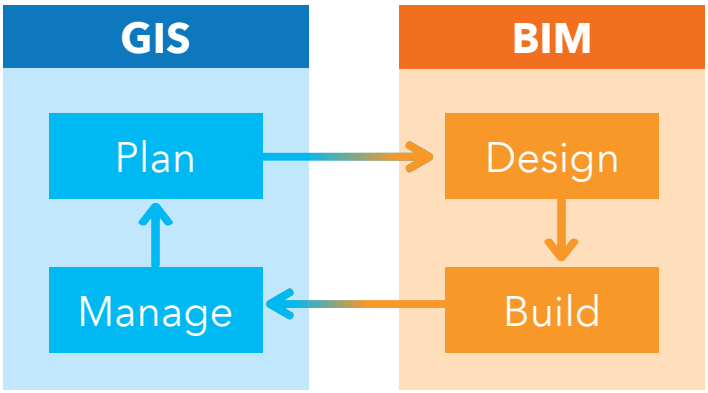
Source: Financial Express

Digital Transformation in AEC

Currently, every industry is going digital, benefiting immensely from digital innovations, and infrastructure is no exception. Digital transformation enables AEC companies to adopt sustainable practices and maximize resource efficiency. Digital tools also enable the implementation of lean construction principles, which aim to reduce waste and improve productivity. Through the use of digital workflows and automated processes, companies can streamline construction operations, minimize errors, and eliminate unnecessary rework.

According to the **Geospatial Market in the AEC Industry Report (2019)**, digitalization in building infrastructure helps to save 10%-20% in the entire construction workflow, whereas project time saving is 14%. In transport infrastructure, there is a cost-saving of 15%-23% in the design and engineering phase and 8% in the entire construction workflow, whereas time-saving is around 17%. In industrial infrastructure, the total cost saving is 8%-10% in the construction workflow, and project time saving is about 8%. Apart from these benefits, digitalization also improves collaboration, enhances clarity, and makes construction sites safer.

Today's smart infrastructure projects necessarily warrant the usage of advanced technologies such as Geographic Information Systems (GIS),



Building Information Modelling (BIM), Drones, Digital Twins, etc. **BIM** has gained significant prominence in AEC, enabling architects, engineers, and contractors to create digital representations of the physical and functional characteristics of a facility. The government's mandate for the adoption of BIM in public infrastructure projects and the increasing awareness and benefits of BIM among industry stakeholders have contributed to its widespread adoption in the Indian AEC industry.

GIS aids in spatial analysis, site selection, land management, infrastructure planning, and environmental assessment. Its capabilities to capture, store, analyze, and visualize spatial data facilitate informed decision-making, efficient resource allocation, and sustainable development in AEC projects.

Drones and remote sensing technologies are increasingly utilized in AEC projects for site surveying, aerial mapping, progress monitoring, inspection, and documentation. Drones enable stakeholders to capture high-resolution aerial imagery, generate 3D models, conduct site surveys, monitor construction progress, and improve safety and efficiency on construction sites. **Site Scan for ArcGIS** is a cloud-based drone mapping software designed to revolutionize imagery data collection, processing, and analysis for smaller sites.

VR and AR technologies are gaining prominence in AEC for design visualization, stakeholder engagement, virtual tours, simulation, training, and marketing purposes. VR and AR enable stakeholders to experience and interact with virtual models, walkthroughs, and simulations, facilitating better design understanding, decision-making, and collaboration.

The concept of **Digital Twins** is evolving rapidly in India across various sectors like AEC, manufacturing, and healthcare, enabling stakeholders to create digital replicas of physical assets, systems, or processes, visualize, analyze, optimize, and simulate scenarios, improve decision-making, enhance operational efficiency, and drive innovation with sustainable & resilient solutions. **ArcGIS CityEngine** is an advanced 3D modeling software used for creating massive, interactive, and immersive urban environments based on real-world GIS data with the potential to showcase a fictional city of the past, present, or future. **ArcGIS Utility Network** provides a comprehensive framework of functionality for the modeling of utility systems such as electric, gas, water, stormwater, wastewater, and telecommunications. It allows users to build real-world behavior into the network features they model.

GIS in Plan, Design, Build, and Operate

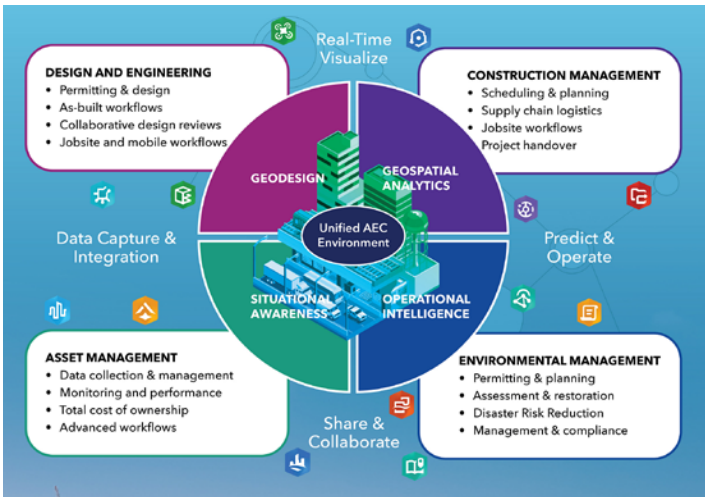
Modern infrastructure projects are very complex, span over multiple years, and require very careful planning and execution. Very often this means access to large amounts of data in real time. Unfortunately, in the absence of an effective information management system, a huge amount of time is spent on locating and validating the data. This not only leads to poor communication but also cost overruns. Effective data and communication management is, thus, very important for not only saving on the direct costs of the projects but also for ensuring statutory compliances (e.g. environmental), timely completion, and avoiding associated penalties and levies. Engineering information systems benefit a lot by using GIS, and today, many projects leverage GIS over the whole lifecycle — planning, survey, construction, operations, and maintenance. ArcGIS Urban facilitates the application of GIS technology to urban planning, helping users to streamline plan creation, analyze the impact of plans, visualize current projects, and facilitate public engagement.

GIS plays a crucial role in assisting project teams in site selection and evaluation based on geographical, resource, and environmental factors. It enables building professionals to visualize the landscape, strategically plan structure placements, and harmonize the built environment with nature. This location-based approach proves valuable in planning roadways, railways, and pipeline routes, allowing planners to assess terrain and environmental variables along proposed routes for optimal and environmentally conscious decisions.

For instance, when creating new roads, GIS aids in identifying ideal terrain, flood plains, traffic conditions, weather patterns, and environmentally sensitive locations, influencing construction and mitigation strategies. The integration of context-aware capabilities with IoT sensors, 2D drawings, 3D models, and construction machinery data facilitates real-time geospatial analysis on construction sites. This integration allows for the continuous monitoring and optimization of construction operations, enhancing efficiency, safety, and resource management. ArcGIS GeoPlanner is a web-based planning tool that empowers users to rapidly design city, regional, and landscape-scale scenarios in a collaborative, iterative environment.

Geo-enabling the AEC value chain provides builders with better control over their outcomes while ensuring the right balance between social, economic, and environmental aspects. Esri's ArcGIS portfolio

supports the end-to-end AEC value chain. Recognizing the gravity of the emerging situation and technological heterogeneity in the AEC industry, Esri solutions are conceptualized and developed embracing Findable, Accessible, Interoperable, and Reusable (FAIR) principles. Supported by intelligent mapping and data capture tools for Geodesign, intuitive visualization for enhanced situational awareness, advanced geospatial analytics for operational intelligence that is actionable, and multi-mode dissemination for sharing and collaboration among stakeholders, ArcGIS AEC solutions foster transparency, efficiency, and cost optimization across the value chain.



Effective Planning and Management of Ports using ArcGIS

Adani Enterprises Limited is using a GIS-based web application as a centralized control 'Land Information System' that acts as a repository of land assets and resources. The Land & Estate department of the company has created a GIS-based system that facilitates master planning and management of multiple ports.

An infrastructural marvel, the mega port at Mundra is a major economic gateway that caters to the northern hinterland of India with multimodal connectivity. The department has incorporated a major project of Mundra Master Planning & and its Development using GIS systems.

GIS has played a crucial role in planning the development of a very important Port, an industrial Hub, and the supporting social and physical infrastructure.

The data was collated, processed, and developed using ArcGIS software, and the solution was deployed using the Portal for ArcGIS technology which helped the organization to analyze the current operation and development situation of the port, industrial hub, and social infrastructure and make decisions about the existing deficiency and expansion, needs of improvements and future development with their management support.

Bringing GIS and BIM Together

As digital interventions make their way into the AEC sector, activities can no longer be carried out in isolation. Being myopic to the construction sites alone is no longer tenable. The need for contextual understanding to demystify the interdependencies and linkages in the infrastructure environs is greater than ever.

BIM and GIS technologies have traditionally operated in silos, with BIM focusing on detailed building design, construction, and facility management, while GIS focuses on spatial analysis, mapping, and geographic data management. Integrating GIS with BIM facilitates better contextualization of the infrastructure and its surroundings. The integration has emerged as a transformative approach in the AEC industry, bridging the gap between building design and spatial analysis to facilitate more informed decision-making, collaboration, and project outcomes. It involves converging building information with geographic data, creating a comprehensive and integrated digital twin of the built environment, encompassing both the indoor and outdoor aspects of infrastructure and building projects.

BIM-GIS integration fosters collaborative workflows and processes in the lifecycle of projects. Integrated workflows enable stakeholders to share, access, analyze, visualize, and collaborate on building information, geographic data, design models, spatial analysis, and project documentation in real-time, enhancing communication, coordination, integration, and collaboration.

> "The amalgamation of BIM and GIS transforms traditional decision-making with an enhanced collaborative approach for the industry by providing a unified platform to access, share, analyze, visualize, and collaborate on building information, geographic data, design models, spatial analysis, and project documentation."

This integration leads to optimized planning and design enhancing project feasibility, sustainability, resilience, functionality, aesthetics, and value.

The integration also leads to substantial cost savings. By combining BIM with GIS, project teams can identify and address issues during the planning phase by creating detailed 3D representations of infrastructure projects. This proactive approach, supported by GIS, minimizes expensive rework, material wastage, and resource inefficiencies. Utilizing IoT sensors for monitoring equipment performance and maintenance, alongside GIS analysis, further contributes to cost savings. The early detection of equipment issues, facilitated by GIS, enables preventive maintenance, eliminating the need for costly breakdown repairs. Additionally, optimizing resource allocation through real-

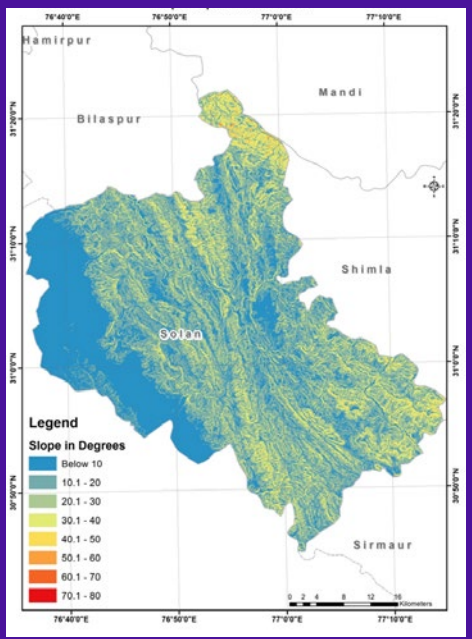
time data, made possible by GIS, can lead to reductions in energy and resource costs, ultimately enhancing overall business profits.

Esri's ArcGIS GeoBIM enables organizations to provide rich geospatial context to architecture, engineering, construction, and facility management projects. By bringing GIS and BIM data together, ArcGIS GeoBIM allows users to incorporate and use data from multiple systems, access project data from a common experience, explore GIS and BIM data side by side, collaborate and share information with stakeholders, and minimize costly data conversions. Using AEC Project Delivery, users can extend internal GIS content and context to resources outside of the organization. This allows them to collaborate and share information directly with stakeholders.

GIS takes BIM to new levels by providing real-time data about an asset's existing environment. Integration of BIM and GIS leads to the creation of a robust model where geographic and infrastructural design information is put together. This information helps designers and engineers to explore and evaluate the design and construction more effectively. An information-rich model can also be used to improvise all the assets within a larger area for operations and maintenance. The benefits of this integration are manifold.

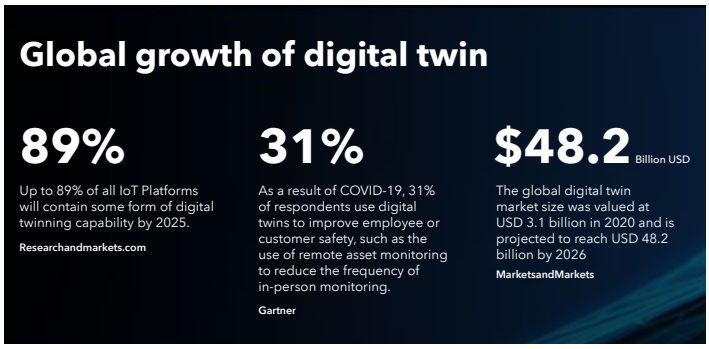
Solar Power Plant Sites Identification using ArcGIS

AGiSAC carried out a study to identify suitable plots of land for PV plant installation. Disparate datasets such as imagery, DEM, land use, settlement clusters, and locations of existing infrastructure such as roads and electricity sub-stations were used in ArcGIS Pro spatial overlay analysis to find suitable sites along with solar power potential calculated in MW.



Digital Twins in AEC

A technology that's increasingly enabling the AEC sector to perform better is "Digital Twin Technology".



Digital twins are virtual representations of the real world including physical objects, processes, relationships, and behaviors. For the AEC industry, a digital twin is in the form of a built asset. Take, for example, an office building and its digital twin. At the end of design and construction, there is an exact, digital replica of the entire building, from the roof to the HVAC system and MEP. The actual, physical building is mirrored as a "twin" in a digital, dynamic format. Unlike a digital model or a simulation, a digital twin isn't static. Just as the final, completed office building changes with use, so does the digital twin. It is responsive and continues to evolve as more data is supplied to it, such as data from artificial intelligence (AI), sensors, or the Internet of Things. That means it can also simulate and predict informed decisions based on real-world conditions of the building.

Digital twin isn't a "one and done" exercise, and there are different levels of use. A digital twin for one project may be more simplistic with editable data, while another may be a fully mature use with enhanced simulations. But the core benefits remain the same. From the beginning of a project throughout the entire life cycle of an asset, a digital twin continues to live, grow, and provide new insights for better ROI, energy savings, maintenance, and performance. This is the basis of a digital twin. A digital twin for AEC is a dynamic, up-to-date replica of a physical asset or set of assets—whether it's a building, a campus, a city, or a railway—that brings together design, construction, and operational data.

With advancements in 3D modeling and simulations, Digital Twins are increasingly assuming greater significance in the AEC workflows. The proliferation of IoT sensors and devices is providing accurate insights for enhanced location awareness and response. Smart applications streaming real-time insights into ArcGIS enable seamless monitoring and administration of the construction processes, facility management, and environmental monitoring.

Interconnecting GIS and Digital Twins

A digital twin benefits directly from the integration with GIS technology. GIS adds spatial context around the asset, connecting the information model to other models and its surroundings. AEC firms are increasingly leveraging the idea of integrating GIS and digital twins for abstracting and modeling everything to enhance business processes, mitigate risk, optimize operational efficiencies, and boost decision-making.

> “Digital twins are abstracting and modeling everything. They offer a means to improve business processes, reduce risk, optimize operational efficiencies, and enhance decision-making with automation to predict future outcomes. ArcGIS technology is the foundation for digital twins.”

Opportunely, there is an array of GIS products that are being utilized for digital twin deployment, including **ArcGIS Urban, ArcGIS Indoors, ArcGIS CityEngine, ArcGIS Velocity, and ArcGIS Reality.**

The convergence of GIS technology, IoT, and BIM is creating interactive 3D visualizations, which are redefining the digital twin as well as the value it brings to organizations. A digital twin is not a single product or solution—it is a complex network of technologies and systems. It must work in harmony to achieve the desired transformational outcomes and return on investment that organizations desire. As digital twin adoption increases, the possibilities and applications of digital twins continue to evolve and create value in almost every industry and organization.

The evolution of GIS technology and the deployment of IoT sensors have resulted in unprecedented amounts of data, which can now be processed, analyzed, and visualized in innovative ways. As IoT and GIS adoption increases and their applications mature, the future is becoming increasingly intelligent and automated. GIS and IoT technologies are connecting systems and data in new ways, enabling the transformation of many organizational workflows. The innovation and integration of these technologies are creating a modern digital nervous system and enabling real-time integrated digital twins.

In Closing

Gauging the vital role, the infrastructure industry has to play in India’s growth story, the Indian Government is greatly emphasizing the enhancement of this sector. Infrastructure is a key focus area for India in the next 25 years as the country aims to emerge as a developed nation by 2047. Enabling steps like the Smart City Mission, National Infrastructure Pipeline, and Gati Shakti, are booster programs for the infrastructure industry. The time is very conducive for the growth of the AEC industry, provided they undergo digital transformation at a faster pace. Technologies such as BIM, GIS, and Digital Twins have the potential to enable the AEC industry to achieve smarter outcomes and help build a resilient and sustainable India. The convergence of these technologies is redefining the possibilities of how they may be used to model, manage, and simulate single facilities, entire cities, and even large natural systems.

As climate change clouds uncertainties on the future, building climate-resilient infrastructure becomes inevitable for sustained economic growth. With the influence of technological advancements on one side and climate change events on the other, it is important that we can assess, visualize, quantify, predict, and prepare for the change in our infrastructure ecosystems in advance and adapt with time. This is the only way we will be able to manage the uncertainties before the pressures build up.

There is no doubt that contextualized geo-intelligence delivered by modern GIS is the foundation for infrastructure that is intelligent, data-centric, and dynamic. Decision-makers are already taking a geographic approach, and infrastructure systems are being integrated with geospatial technology including GeoBIM, digital twins, sensors, and advanced spatial analytics. Accordingly, we are now creating ‘smart infrastructure.’ Through smart infrastructure, we are forging an ecosystem that bridges the gap between the physical realm and the digital domain. As the AEC industry leverages the next generation of tech — GIS integrated with advanced technologies like AI, IoT, Cloud Computing will be an integral component of the revolution, and we will continue to witness exciting developments in the realm of smart infrastructure.

CASE STUDY

Revolutionizing Irrigation Pipeline Design using ArcGIS

Client
L&T Construction's Water & Effluent Treatment IC

Industry
AEC

Organization Profile
L&T Construction's Water & Effluent Treatment business vertical provides state-of-the-art design, detailed engineering, procurement, project management, project execution, commissioning and operation & maintenance for: Water Transmission, Treatment; Distribution and Management; Municipal Used Water Collection Treatment and Reuse; Industrial Water Treatment to achieve Ultra-Pure Water; Industrial Effluent Treatment and Zero Liquid Discharge / Recycle; Desalination Plants - Sea Water / Brackish Water; "Unaccounted for Water" Projects to Monitor the Water Loss; Lift Irrigation Projects; Refurbishments of Treatment Plants; Canal Relining projects. With a fiscally sound approach to projects, proven project management skills, country wide operational presence, and an experience & expertise that spans over 40 years, L&T is recognized as the leader in developing and providing water infrastructure in the country.

Solution
Irrigation Pipeline Design

Website
www.lntecc.com

Project Summary

In recent times, lift irrigation projects have emerged as a popular solution for supplying water to agricultural lands at elevations higher than the source of water. The integration of GIS into irrigation projects has revolutionized the way these projects are planned, designed, and managed in India. The technology can also be used to automate various processes and tasks in the lift irrigation project lifecycle. The successful implementation of ArcGIS products in the Lower Suktel Irrigation project serves as a case study showcasing the potential of GIS in such endeavors. The case study highlights how GIS facilitated the design and execution of the project, offering insights into how this technology streamlined the process and contributed to the project's success. By leveraging GIS technology, the project was able to achieve a more streamlined and effective execution, ensuring that the irrigation system is not only well-designed but also optimized for cost savings and operational efficiency. The ability to cater to a large cultivable area and incorporate micro irrigation compatibility underscores the scalability and versatility of GIS in irrigation projects.

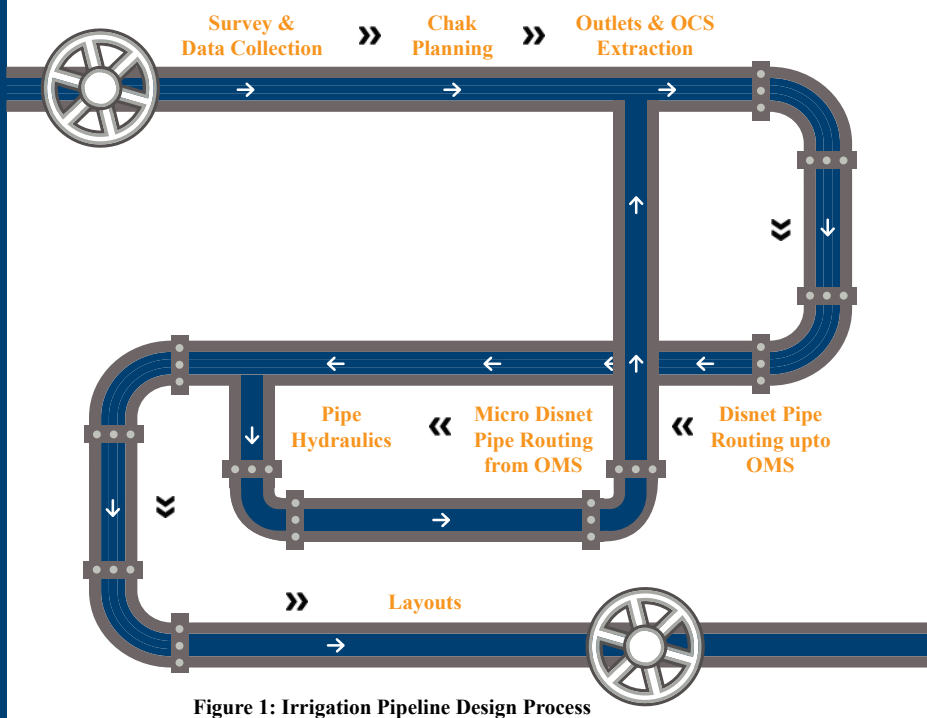


Figure 1: Irrigation Pipeline Design Process

The Lower Suktel Irrigation project in Odisha, with a distribution network of up to 1 ha sub chak compatible with micro irrigation for 27000 hectares of cultivable area, is the subject of this case study, which describes the use of GIS in irrigation pipeline design.

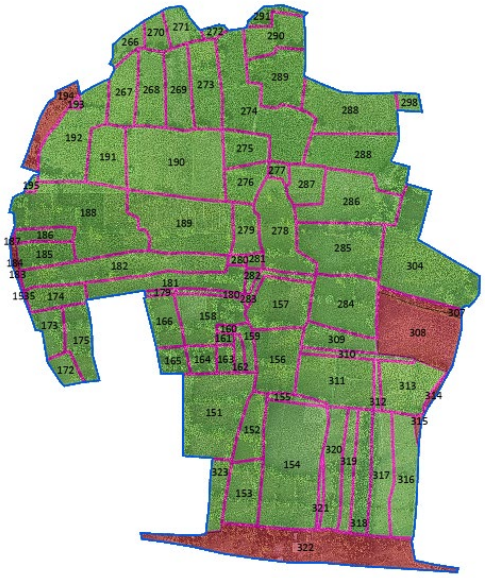
Achieving Optimum Efficiency with GIS

Chak Planning

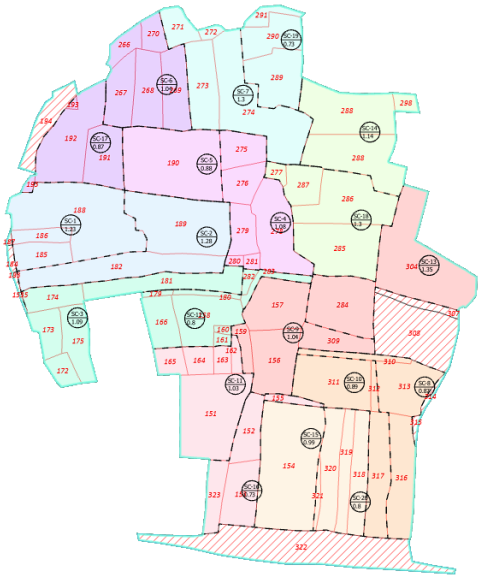
The process of chak planning in irrigation management is undeniably foundational and traditionally labor-intensive. The establishment of layouts for chaks, which serve as basic units within the command of a channel, has conventionally involved significant manual effort using tools like AutoCAD and Excel. This process typically requires merging land records manually, which can be time-consuming and prone to human errors.

The adoption of GIS, particularly through customized tools developed using ArcGIS Model Builder, has proven to be a game-changer in this aspect of irrigation planning. **About 50% of time saving is attained in chak planning process using ArcGIS with minimal manual errors.**

Land Records (ROR) Overlay



Cultivable & Non - Cultivable Making



Sub - Chak Plan
Figure 2: Chak Planning

Distribution Network routing

Assured and timely irrigation water supply is indeed crucial for maximizing agricultural production within a command area. The efficiency of a water delivery system significantly impacts the ability to meet these needs. Designing and constructing a well-planned water delivery system is essential to ensure the efficient functioning of the irrigation network. The implementation of the least cost path analysis (LCPA) as an automated tool for generating a preliminary distribution pipeline network is a significant advancement in the field of pipeline distribution design. LCPA allows for the creation of an optimized distribution pipeline network, ensuring that water is delivered using the most efficient and cost-effective routes. The toolset based on LCPA aids in identifying the least costly path for laying down pipelines, minimizing construction expenses while ensuring a well-connected network. The use of an automated tool for this purpose streamlines the pipeline network design process, reducing manual effort and time while also potentially reducing errors.

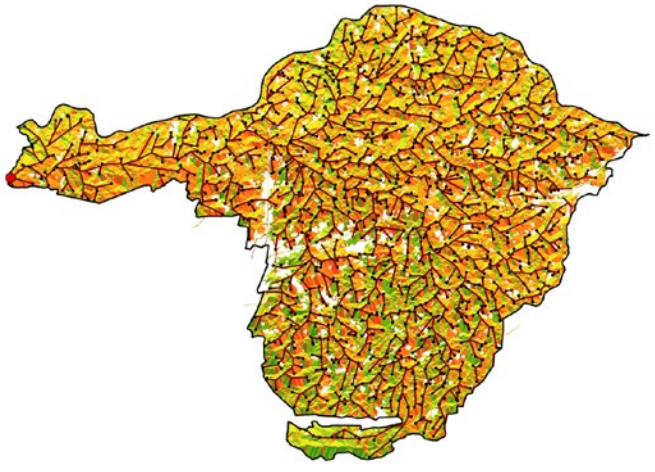


Figure 3: Distribution Network

OCS and Outlet Locations

The utilization of the zonal statistics tool within ArcGIS Pro to develop an in-house automated toolset is a smart approach for irrigation planning and management. This process not only optimizes the placement of sub-chak outlets but also aids in efficiently locating the Outlet Management System (OMS) or Outlet Control System (OCS). By using the zonal statistics tool, the toolset can identify the highest elevation point within a chak. Placing sub-chak outlets at this point ensures efficient water distribution, leveraging gravity to distribute water effectively.

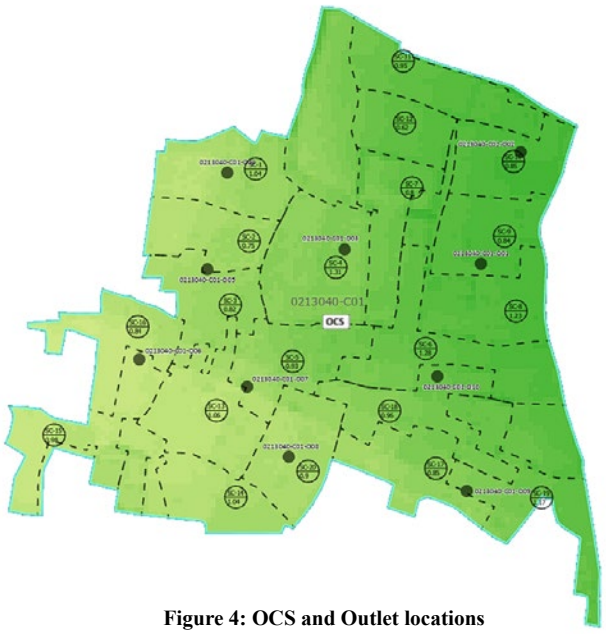


Figure 4: OCS and Outlet locations

Microdisnet Routing

Microdisnet is the pipeline routing from OCS to the outlet of each chak. Leveraging the attribute data, an in-house toolset has been developed to route pipelines from OCS to sub-chak outlets for all the chaks.

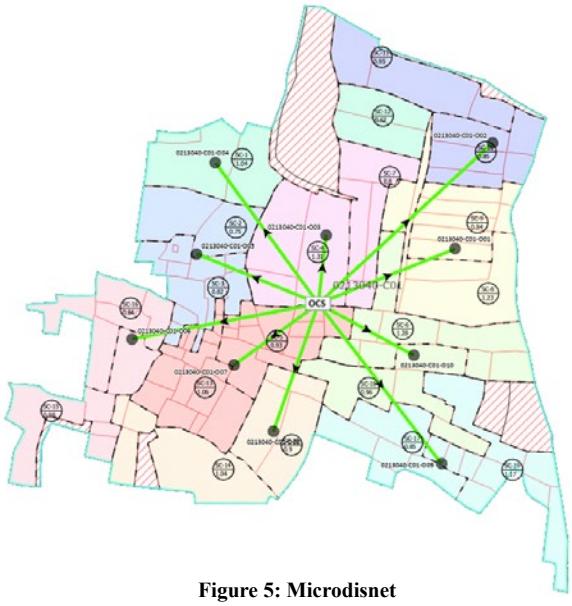


Figure 5: Microdisnet

GIS Layouts for Approvals

Map Series in ArcGIS enables the automated generation and updating of layouts for command maps, index maps, and schematic maps. The layout preparation in ArcGIS is object based and any changes in the design can be seamlessly updated to the entire database. With Map Series, maintaining consistency in layouts across multiple maps becomes efficient.

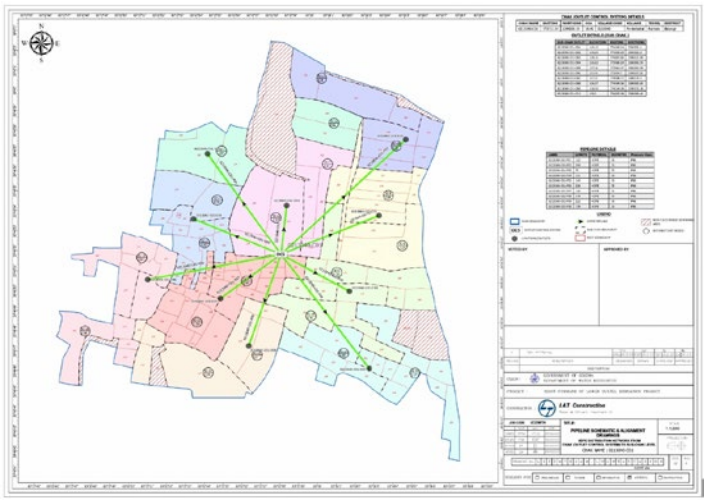


Figure 6: GIS Layouts

Digital Execution

The development of a dashboard using ArcGIS Online involves publishing all design data, including pipeline details, fittings, OMS (Outage Management System), and outlets on the web for streamlined execution. This approach allows site engineers to easily visualize both the data and associated design details directly from the dashboard, enhancing the efficiency of execution.

Progress Monitoring

Monitoring progress via GIS dashboards represents a potent method for visually tracking and analyzing diverse data types across geographical locations. These dashboards provide real-time or near-real-time insights, empowering users to make well-informed decisions based on the latest information.

Overall, the integration of GIS technology in lift irrigation projects has been a game-changer, revolutionizing the way these projects are approached, designed, and managed. The Lower Suktel Irrigation project stands as a testament to the potential of GIS in transforming agricultural irrigation systems.

> ArcGIS empowers the qualitative design of irrigation pipelines by seamlessly integrating spatial data, enabling precise planning and analysis for optimal infrastructure development, ensuring efficient water distribution, supporting sustainable agricultural practices through informed decision-making and resource management.
>
> **– Dr Rajesh Kumar, HEAD - EDRC (DIGITAL), III SBG - WET IC, L&T Construction**

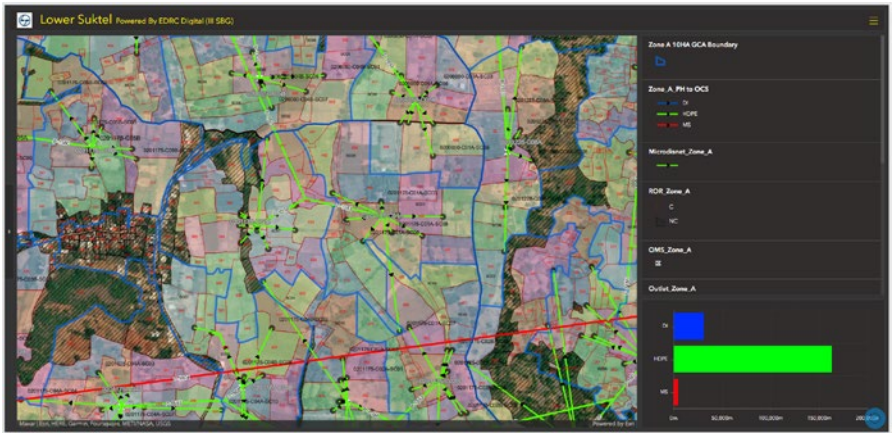


Figure 7: ArcGIS Dashboard Enabling Easy Visualization of Data & Design Details

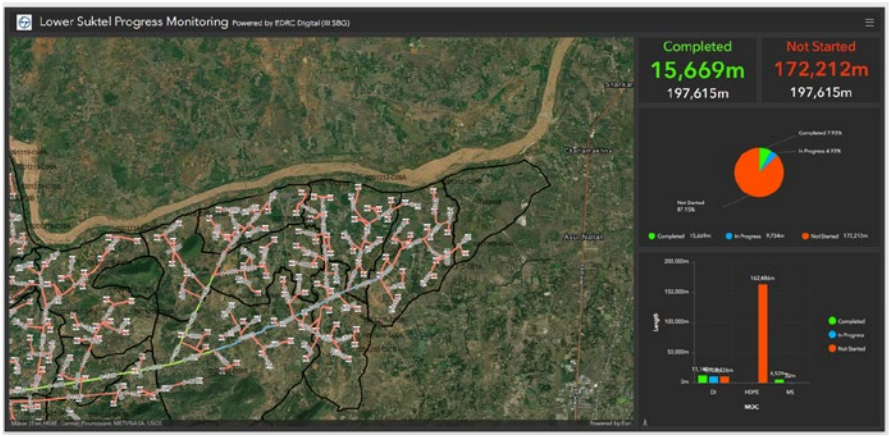
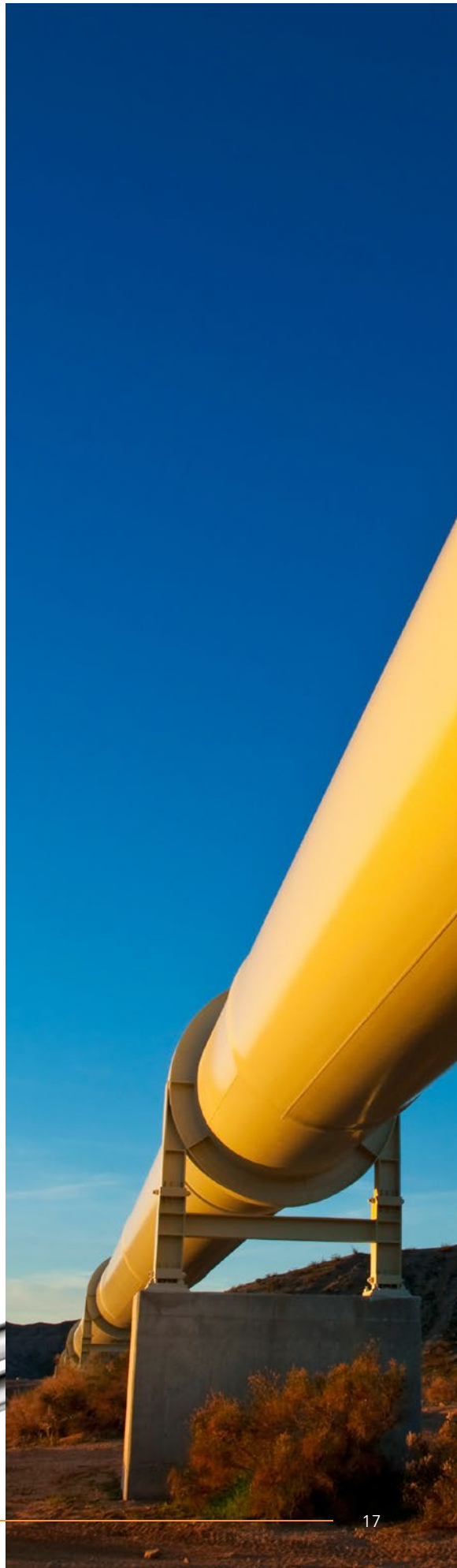


Figure 8: ArcGIS Dashboard Enabling Monitoring the Progress of the Project



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Collaboratively Transforming AEC Projects

The AEC industry in India has experienced significant evolution over the years due to several factors contributing to steady growth, including economic growth, the latest technological advancements, urbanization, and evolving contractual and regulatory landscapes. There is increased adoption of technology, such as Building Information Modeling (BIM), Geographic Information Systems (GIS), and advanced construction techniques, leading to improved project efficiency, accuracy, and collaboration. Digital tools are increasingly being used for project lifecycle management in design, planning, project management, and operations and maintenance.

Additionally, to address the infrastructure development challenges, there's a growing trend towards private sector participation. This helps in attracting investments and accelerating infrastructure development across sectors. Collaboration between government and private sector entities to finance, design, construct, and operate infrastructure projects, aid in leveraging the strengths and resources of both sectors.

Addressing infrastructure sector challenges together

Through a three-decade journey in the AEC industry, Capricot Technologies has been instrumental in shaping the landscape of technology adoption, initially playing a pivotal role in driving the adoption of Computer-Aided Design (CAD) in the country. Today, its focus extends to comprehensive information modeling, addressing end-to-end challenges faced by the building and infrastructure sectors.

> "Capricot Technologies' partnership with Esri India has been transformative, enabling the company to deliver integrated solutions that seamlessly blend spatial intelligence with the built environment and geographic context. The solutions have been empowering AEC professionals to make informed decisions by assessing the impact of designs on the surrounding environment, including considerations for urban planning, environmental impact assessments, and the holistic development of infrastructure."

Transforming AEC Projects with GIS

The use of GIS in AEC is transforming the traditional ways used to plan, design, construct, manage, and operate infrastructure and building projects.

Initially, GIS was primarily used for mapping and spatial analysis in the AEC industry. However, its adoption has expanded to support integrated planning and design processes, enabling stakeholders to analyze spatial relationships, site conditions, environmental factors, land use patterns, and infrastructure networks to inform decision-making and optimize design solutions.

GIS provides a centralized platform to access, share, analyze, and visualize geospatial data, design information, project documentation, and

stakeholder feedback in real-time, fostering transparency, coordination, and collaboration across project teams.

The integration of BIM and GIS has also emerged as a transformative approach in the AEC industry, bridging the gap between building design and spatial analysis to facilitate more informed decision-making, collaboration, and project outcomes. BIM-GIS integration fosters collaborative workflows and processes in the lifecycle of projects. Integrated workflows enable stakeholders to share, access, analyze, visualize, and collaborate on building information, geographic data, design models, spatial analysis, and project documentation in real time, enhancing communication, coordination, integration, and collaboration.

AEC firms in India are expected to increasingly leverage GIS in the next few years to enhance smart urban planning and development, optimize infrastructure asset management, and incorporate sustainability and resilience principles into design and construction practices.

Other technologies that are gaining a lot of prominence in AEC include drones and remote sensing technologies, VR and AR technologies, Cloud computing and collaboration platforms, and Digital Twins. Drones enable stakeholders to capture high-resolution aerial imagery, generate 3D models, conduct site surveys, monitor construction progress, and improve safety and efficiency on construction sites. Cloud computing and collaboration platforms have become essential digital tools in AEC projects for data storage, sharing, collaboration, communication, and project management. They enable stakeholders to access project information, documents, and tools anytime, anywhere, facilitate real-time collaboration, streamline workflows, and ensure seamless communication among project teams and stakeholders.

Also, the concept of Digital Twins is evolving rapidly in India across various sectors like AEC, manufacturing, and healthcare enabling stakeholders to create digital replicas of physical assets, systems, or processes, visualize, analyze, optimize, and simulate scenarios, improve decision-making, enhance operational efficiency, drive innovation with sustainable & resilient solutions.

As AEC organizations continue to embrace digital transformation, the adoption and impact of these technologies are expected to grow exponentially, shaping the future of India's economy, society, and environment.

Capricot Technologies foresees robust growth in the coming years, with key players in the industry adopting integrated solutions. The incorporation of data-rich models and seamless integrations provides a comprehensive toolkit for the AEC sector, allowing professionals to navigate and excel in complex projects with efficiency and precision.

GIS Fostering Urban Development –A Dialogue with Mr. Durgesh Kumar, Consultant (IT), Municipal Corporation of Delhi

Mr. Durgesh Kumar
Consultant (IT), Municipal Corporation of Delhi

Please explain in brief the role of MCD in developing the State's infrastructure.

The Municipal Corporation of Delhi (MCD) spreads over an area of about 1400 sq. km. which is approximately 97% of the total area of the Government of National Capital Territory of Delhi (GNCTD). The primary responsibility of the Corporation is to provide basic amenities (mainly sanitation & hygiene) to the citizens and also enhance infrastructure facilities as per the requirement of an area. MCD plays a vital role in implementing various infrastructure development projects in the State. It actively engages in improving infrastructure such as roads, stormwater drains, parks, streetlights, and other essential amenities like public and community toilet facilities in urban areas of public importance.

According to you, how does GIS aid in better infrastructure development?

Geographic Information System (GIS) plays a crucial role in infrastructure development by providing a powerful tool for planning, designing, implementing, and managing various aspects of infrastructure projects. Here are some key roles of GIS in infrastructure development:

Spatial Analysis and Planning: GIS allows planners to analyze spatial data, understand geographical patterns, and make informed decisions about the optimal locations for infrastructure projects. It helps in identifying suitable sites for new developments, taking into account factors such as environmental impact, accessibility, and land use.

Site Selection and Design: GIS aids in site selection by integrating various layers of spatial information, such as topography, land use, and environmental constraints. Engineers and designers can use GIS to create accurate and detailed maps, facilitating the design and layout of infrastructure projects.

Data Integration and Visualization: GIS enables the integration of diverse data sources, including satellite imagery, demographic data, and infrastructure inventories. This integration helps in creating comprehensive datasets for decision-making. Visualization tools in GIS allow stakeholders to view complex data in a visually understandable manner, aiding in communication and collaboration.

Infrastructure Asset Management: GIS is used for inventory management and maintenance planning of infrastructure assets. It helps in tracking the condition, performance, and life cycle of various components. Asset mapping through GIS assists in prioritizing maintenance and replacement activities based on the geographic distribution and criticality of assets.

Environmental Impact Assessment: GIS is instrumental in conducting environmental impact assessments for infrastructure projects. It helps in analyzing and mitigating potential environmental effects by considering factors such as terrain, water bodies, and habitats.

Transportation Planning: GIS is widely used in transportation planning for road and transit network optimization by development of new high-level overpass. It helps in analyzing traffic patterns, optimizing routes, and improving overall transportation efficiency.

Emergency Management: GIS plays a crucial role in emergency response and management. It helps in identifying critical infrastructure,

assessing vulnerability, and planning for emergency scenarios.

Public Engagement: GIS facilitates public participation in the planning process by providing accessible and interactive maps. It allows stakeholders to understand the proposed infrastructure projects and express their opinions.

Decision Support Systems: GIS provides decision-makers with powerful analytical tools to evaluate different scenarios and make informed choices about infrastructure development strategies.

Monitoring and Evaluation: GIS enables real-time monitoring of ongoing infrastructure projects. It helps in tracking progress, identifying potential issues, and evaluating the impact of completed projects.

In summary, GIS enhances the efficiency and effectiveness of infrastructure development by integrating spatial information, supporting decision-making processes, and improving overall project management.

How is MCD using GIS in its work?

MCD uses GIS to analyze and interpret spatial data, aiding in urban planning and development. This includes identifying suitable locations for infrastructure projects, assessing land use patterns, and optimizing spatial resources.

> "The MCD GIS Citizen Portal, which has been developed by Esri India, is a step towards better governance taken by the Municipal Corporation of Delhi to allow the citizens of Delhi to avail the various services through an easy-to-use interface along with geo-referential data. The main purpose of this portal is to provide a planning tool and updated information for departmental officers to design their projects/ schemes that help in delivering hassle-free, transparent, and efficient services to its citizens. The insights provided additionally aid in the planning and monitoring of various developmental initiatives."

What have been the most significant benefits of using the GIS Citizen Portal?

Under the conventional system, MCD faced numerous challenges in effectively managing its widely dispersed resources and assets. Access to critical data was restrained within specific zones and wards jurisdictions, relying primarily on different computer systems, Excel files, and paper-based workflows. The absence of an efficient and consolidated monitoring mechanism contributed to an uneven distribution of resources and a fragmented understanding of the overall area. Consequently, budget allocations for the improvement of MCD's jurisdiction exhibited inconsistency, obstructing the seamless implementation of targeted developmental initiatives. Furthermore, the decision-making process suffered from siloed information and the unavailability of a structured visualization tool, resulting in limited analytical insights and hindrances in strategic planning. The constraints of the conventional system were a significant challenge to MCD's capacity to efficiently manage resources and make well-informed decisions.

Esri India's holistic solution has efficiently resolved the challenges faced by MCD through a single window-enabled GIS portal. It has offered the following major benefits:

Visualization of MCD Assets and Properties: The GIS solution enables the visualization of MCD assets and properties with metadata on a comprehensive GIS map, incorporating essential geodata for enhanced spatial analysis and informed decision-making.

Integration with Online Applications: The system's integration with various online applications enables the display of real-time visualization of thematic maps, providing updated status information for tower permission applications, property tax, licenses, and other relevant processes, ensuring transparency and streamlined workflow.

Simplified Information Management: The GIS tool simplifies the overall process of compiling, handling, manipulating, interpreting, and distributing information for the department, fostering improved data management and operational efficiency.

Enhanced Communication and Decision-Making: The strengthened communication and decision-making systems facilitated by the GIS solution promote better collaboration among stakeholders, leading to more informed and effective decision-making processes within the MCD.

Streamlined Resource Management: The sourced information through the GIS platform significantly eases day-to-day resource management, providing valuable insights for efficient resource allocation and utilization, thereby improving operational efficacy and resource optimization.

How has been your experience working with Esri India?

It has been a phenomenal experience. After implementing the new GIS solution, MCD as an organization has been able to take a leap in its service delivery. All the existing raw data integrated into the new system has enabled us to use it in various departmental activities, planning, and visualization. The near real-time data integration provides daily base data updates along with analysis and comparisons on maps as well as analytical charts, which further ease the monitoring capabilities of the officers. Moreover, Heat Maps generated with the help of the GIS system, are useful in identifying more prone areas falling under any schemes to provide more thrust-by-field functionalities. This system will surely reflect in the ROI outcome of MCD in the coming years.

GIS-powered Digital Twins

Transforming Operations & Decision-Making

A digital twin is a virtual representation of the real world, including physical objects, processes, relationships, and behaviors, making it a perfect digital replica of the physical world. GIS creates the data mesh for digital twins, by uniquely integrating multiple types of digital models – it interconnects information, systems, models, and behaviors with spatial context, thereby creating holistic digital representations of environments, assets, networks, and cities.

Today, the business ecosystem is leveraging the idea of integrating GIS-empowered digital twins for abstracting and modeling everything to enhance business processes, mitigate risk, optimize operational efficiencies, and boost decision-making with automation to predict outcomes. Digital twins tend to serve more purposes, not only for solving business challenges but also for generating economic growth, while simultaneously creating relationships and streamlining workflows. The emergence of Industry 4.0 and IoT has accelerated the adoption of the digital twin technology across industries. Currently, the digital twin technology meets the requirements of various users in government as well as private sectors like telecommunications, utilities, etc. 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 fueling Digital Twin Technology

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.

Today, retail, manufacturing, supply chain, healthcare, renewable energy, construction, aerospace, and climate change are all being served by digital twins. It has evolved into a tool for developing enhanced virtual, real-time, and AI-driven models of real-world applications, for curating intelligent decisions for real-world problems. For example, as the 5G revolution starts taking shape, it will necessitate a denser telecom network with more judiciously and unequivocally deployed towers.

> “GIS data powers many simulations of real-world dynamics and behaviors. 3D GIS provides dynamic, easy-to-use experiences in a web browser for simple analyses. For complex analyses, advanced geoprocessing workflows may be used to simulate changes in large utility networks and then to see those changes in a simple dashboard. Using GIS, one can map the utilities running near the project site, both over and under the ground, and tackle them effectively during construction. It also helps in handling other tasks like finding optimal routes for raw material deliveries and disposing of construction waste and excess material. These decisions can be taken easily using the techniques of GIS.”

This will call for improved spatial analytics - powered by digital twins. Digital Twins that are based on GIS have features that are geo-referenced. These georeferenced features make the digital twin powerful tools for analyzing, visualizing, and simulating geospatial data and phenomena, enabling better understanding and decision-making in various domains such as urban planning, infrastructure management, environmental analysis, and emergency response. Esri offers an array of GIS products that are being utilized for digital twin deployment, including ArcGIS Urban, ArcGIS Indoors, ArcGIS CityEngine, and ArcGIS Reality.

ArcGIS Urban enables planners and design professionals to collaborate across teams with a web-based 3D application that supports scenario planning and impact assessment. ArcGIS Urban enables the digital transformation of city and regional planning to encourage collaboration with community stakeholders and help all groups work toward a more sustainable future.

ArcGIS Indoors enables organizations to build an indoor geographic information system (GIS) and put the power of indoor mapping, wayfinding, and space management software into everyone’s hands. With three license levels available, ArcGIS Indoors Pro, Indoors Maps, and Indoors Spaces, organizations can consolidate their asset and space nformation into a single place, the indoor map, and provide easily accessible web and mobile apps, for location discovery, wayfinding, room reservations, and space planning.

ArcGIS CityEngine is advanced 3D modeling software for creating massive, interactive, and immersive urban environments in less time

than with traditional modeling techniques. The cities that are created using ArcGIS CityEngine can be based on real-world GIS data or showcase a fictional city of the past, present, or future.

ArcGIS Reality is a suite of photogrammetry software products designed to enable reality capture workflows for sites, cities, and countries. With ArcGIS Reality, organizations can turn drone and aerial imagery into visually stunning and highly accurate maps and 3D models. They can interact with a digital world that shows places and situations as they truly are, layered with geospatial data that enriches reality with greater context.

> “There has been a remarkable uptick in the trend of solving real-world problems with customized GIS solutions and resultantly, trends like GeoAI, GIS on Cloud, and digital twins, are witnessing accelerated popularity. The reason behind this accelerated utilization revolves around the numerous advantages they provide for the users, with digital twins resulting in less waste, shorter times to market, shorter development time, and constant customer insights. The technology allows for rapid iterations and optimizations of product designs far faster than physically testing every single prototype.”

The advantages of applying digital twins become important for government programs like Gati Shakti, as they help in better designs, cost management, multi-agency coordination, and cutting down project timelines. From enabling better planning, management, and governance, to providing improved and secure solutions for industries and masses alike, the digital twin concept is being valued for what it can really do. In all of this, software such as ArcGIS provides out-of-the-box solutions that enable the creation, visualization, and analysis of digital twins.

However, though the digital twin is a cutting-edge technology that has revolutionized the business ecosystem by mirroring almost every facet of a product, process, or service, the technology also faces its share of challenges. These include data standardization, data management, and data security, as well as barriers to its implementation. The high cost of deployment, increased demand for power and storage, integration challenges with existing systems, and complexity of its architecture are indeed slowing down the growth of the digital twin market. These issues cannot be addressed in silos. The government and industry should join hands to evaluate and optimize the performance of physical systems to draw out the most from this technology.

ArcGIS GeoBIM

Connecting projects in context

ArcGIS GeoBIM is a solution for exploring building information modeling (BIM) models, engineering documents, and project management issues in a geographic context to analyze risks, costs, and timelines. ArcGIS GeoBIM allows you to integrate and visualize GIS data with engineering documents to make coordinated decisions across project teams.

With ArcGIS GeoBIM, you can do the following:

- Manage data by automatically georeferencing BIM documents, issues, and projects into hosted feature layers.
- Link Autodesk BIM 360 or Autodesk Construction Cloud data to features in ArcGIS web maps and web scenes to help you find detailed BIM and engineering information after locating it in a geographic context.
- Create apps using configurable templates that you can use to query, visualize, locate, and view the location of engineering documents, issues, and projects and to view complete, up-to-date engineering details for one or more projects.
- Collaborate on design coordination, planning across time, and issue management.
- Visualize geographic features and BIM objects side by side to show relative context of the projects.
- Manage issues with dashboards to visualize risk, safety, and performance of issues in one or more BIM projects.
- Integrate ArcGIS GeoBIM with ArcGIS Field Maps for field operations.

The ArcGIS GeoBIM user experience consists of two components: the ArcGIS GeoBIM Project Manager and one or more ArcGIS GeoBIM apps.

ArcGIS GeoBIM Project Manager

The ArcGIS GeoBIM Project Manager allows you to create ArcGIS GeoBIM apps. This is the page that appears after you click the project on the landing page. There are five components (pages) that you need to create a project in the Project Manager: the Accounts page, the Tools page, the Links page, the Apps page, and the Maps page.

Tools page

The Tools page has been designed to provide a schematic interaction with the synchronization operations that can be performed by selecting the needed process and choosing the appropriate settings for it. You can get the latest feedback on the operations by refreshing and checking the layers added to the page table.

The panel on the left side allows you to select what tools to run, to apply custom properties for each tool or to perform special GIS analysis for the synchronized data. Each tool card has a settings icon on the lower-right side that will open custom properties and settings that you can apply to the tool.

The Locate Engineering Documents tool allows you to locate CAD and BIM documents on a map and create polygons that show the extent of these models. This tool also allows you to perform and apply an outlier analysis to the synchronized documents. Given the tool complexity and the possibility of having the documents in BIM 360 or Autodesk Construction Cloud with an incorrectly defined WKID, an invalid one or none, this GIS analysis provides a better understanding of the data by flagging the outliers in the map.

The Locate Issues tool allows you to locate design, engineering, and construction issues on a map based on engineering document locations and project addresses. Similar to the Locate Engineering Documents tool, the settings button allows you to use the project address to force synchronization and to add a default WKID to be used inside the tool.

The Create BIM Project Boundaries tool allows you to create BIM project boundaries on a map based on document and issue locations. This tool requires engineering documents data to be already available,

so even if this tool is run in isolation, the engineering documents are synchronized or updated as a prerequisite. Synchronizing the Issues data is optional for this tool to run but recommended and preferred because the output will supply a general view of the geographical context of the entire BIM project and the number of engineering documents and issues belonging to it. The settings button for this tool allows you to select one or more output shapes for the boundary of the BIM project.

Links page

The Links page allows you to add data (web map or web scene) and link BIM 360 or Autodesk Construction Cloud projects to layers and features in the map. The Links page can be accessed by all users but can only be modified by a user with an ArcGIS Online Creator account.

Apps page

The Apps page displays and stores all the apps that you create. Creators can view, edit, and delete apps on this page. ArcGIS GeoBIM has two types of apps: the viewer app and the issues dashboard app.

Maps page

The Maps page displays and stores all web maps associated with an ArcGIS GeoBIM project. After you configure and save an app using the App Editor, the web maps selected for the app are displayed on the Maps page. The Maps page is used to enable ArcGIS Field Maps integration in the ArcGIS GeoBIM project.

ArcGIS GeoBIM app

The ArcGIS GeoBIM app connects web maps, web scenes, and georeferenced BIM 360 project data. The ArcGIS GeoBIM app consists of these elements: the Map widget, the Link Explorer, the Table widget, the Elevation Profile widget, the Editor, and the Details group.

The Map widget is located at the top of the project. It is where your project's web map or web scene appears.

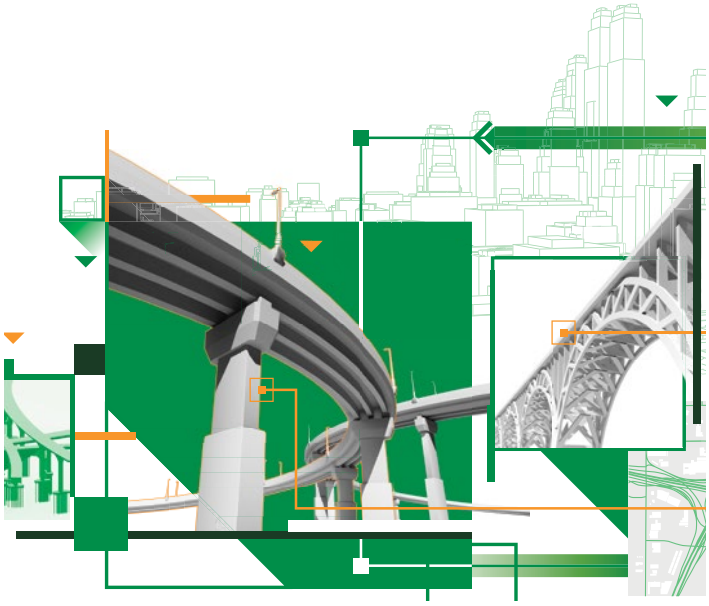
The Link Explorer is located in the Explorer group, and it allows you to link more documents to the features in the Map widget.

The Table widget is located in the Explorer group. The Table widget has these elements: the Documents table, Issues table, Schedules table, Notes tables (Location, Line and Area notes) and BIM Projects table. The Documents table contains the list of documents (models) in the web map or web scene.

The Elevation profile widget is located in the Explorer group. The Elevation Profile widget generates and displays an elevation profile for any line in a web map or web scene.

The Editor is located in the Explorer group. The Editor is used to add custom Note features or edit the geometries of features within the project layers of an ArcGIS GeoBIM app.

The Details group appears on the right when you click the launch button for a specific issue, document, BIM project, or schedule in the Table widget. The Details group provides information on a specific issue, document, BIM project, or schedule in the Table widget. The Details group has four elements: Forge Viewer, Issue Details, BIM Project Details, and Forge Explorer.



Deep Learning with ArcGIS Pro

Deep learning in ArcGIS Pro refers to the integration of deep neural networks and machine learning techniques within the ArcGIS Pro software for geospatial analysis. Deep learning capabilities within ArcGIS Pro enable users to leverage powerful algorithms for tasks such as image classification, object detection, and feature extraction in the context of geospatial data.

A deep learning model package (.dlpk) contains the files and data required to run deep learning inferencing tools for object detection or image classification. The package can be uploaded to your portal as a DLPK item and used as the input to deep learning raster analysis tools.

Deep learning model packages must contain an Esri model definition file (.emd) and a trained model file. The trained model file extension depends on the framework you used to train the model. Depending on the model framework and options you used to train your model, you may need to include a Python raster function (.py) or additional files.

Here are some tips and tricks to help you work with deep learning in ArcGIS Pro:

1. **Data Preparation:**Ensure that your input data is properly prepared. This includes having high-quality, well-organized imagery with accurate labels for training. Use the mosaic dataset in ArcGIS Pro to efficiently manage large volumes of imagery.

2. **Model Selection:** Choose the right deep learning model for your task. ArcGIS Pro supports various pre-trained models such as TensorFlow and PyTorch models. Select the one that best suits your specific use case.

3. **Transfer Learning:** Leverage transfer learning to fine-tune pre-trained models on your specific dataset. This helps when you have limited labeled data for your specific region or task.

4. **Training Parameters:** Adjust training parameters such as learning rate, batch size, and number of epochs to achieve optimal performance. Experiment with different settings to find the best combination for your dataset.

5. **GPU Acceleration:** If possible, use a machine with a compatible GPU to accelerate the training process. This can significantly speed up deep learning workflows.

6. **Data Augmentation:** Apply data augmentation techniques during training to artificially increase the size of your training dataset. This can improve the model's generalization and performance on real-world data.

7. **Monitoring and Visualization:** Monitor the training process using tools provided in ArcGIS Pro. Visualize metrics such as loss and accuracy over time to ensure that the model is learning effectively.

8. **Model Evaluation:** After training, evaluate the model's performance using validation datasets. Use metrics such as precision, recall, and F1 score to assess how well the model is performing.

9. **Exporting and Inference:** Once satisfied with the trained model, export it for use in inference tasks. ArcGIS Pro provides tools to deploy the model and perform predictions on new data.

10. **Continuous Improvement:** Deep learning models can benefit from continuous improvement. Periodically retrain the model with new data to keep it up-to-date and enhance its accuracy over time.

Key uses of Deep Learning in ArcGIS Pro

Deep learning in ArcGIS Pro can be applied to various geospatial tasks, providing advanced capabilities for extracting valuable insights from imagery and spatial data. Here are some key uses of deep learning in ArcGIS Pro:

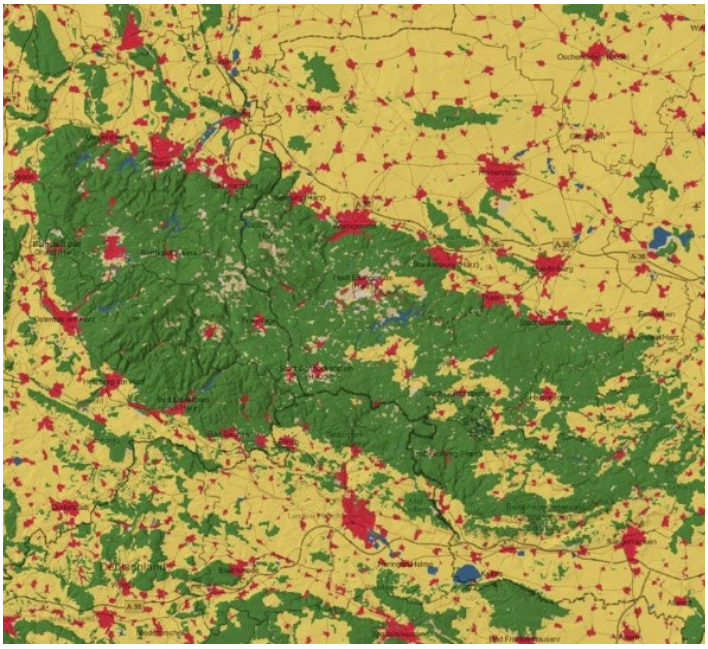
1. **Image Classification:** Deep learning can be used for image classification to categorize pixels in satellite or aerial imagery

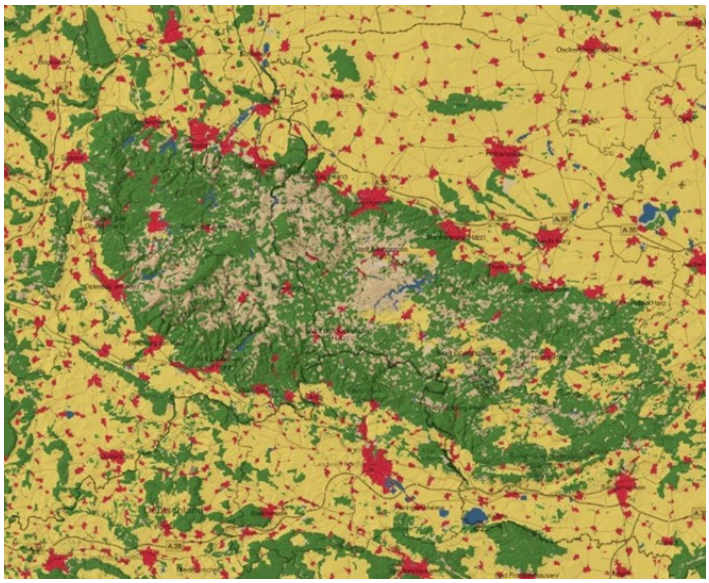
into different land cover classes. This is useful for tasks such as land cover mapping and environmental monitoring.

2. **Object Detection:** Deep learning models enable the detection and localization of specific objects within imagery. This can include identifying buildings, roads, vehicles, and other features in satellite or drone imagery.

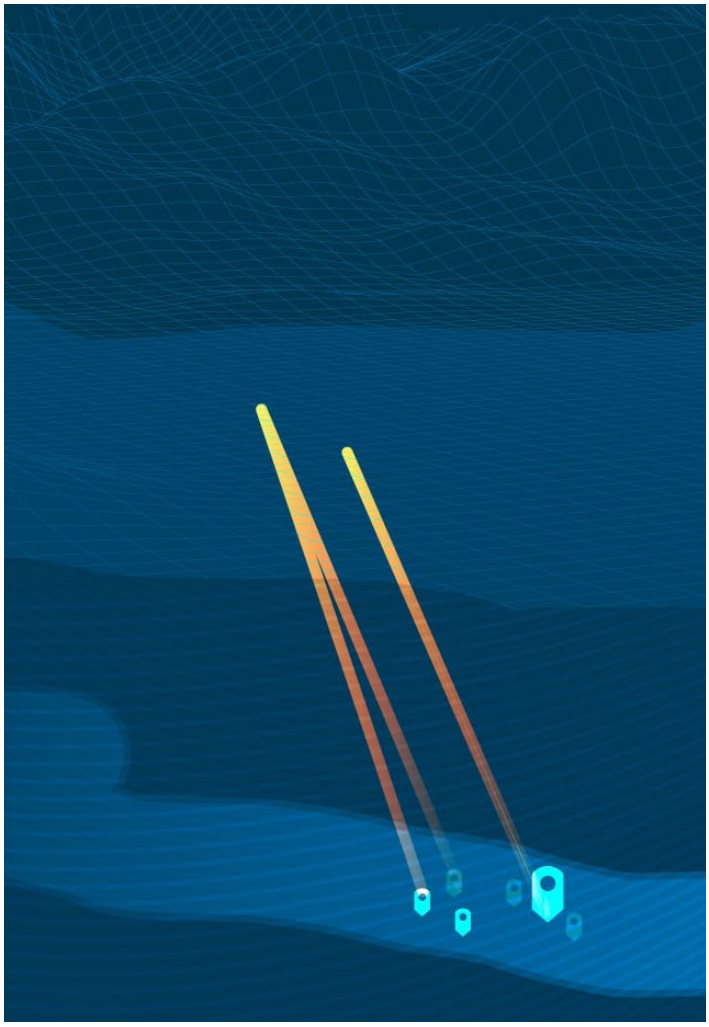
3. **Feature Extraction:** Deep learning can automatically extract features from geospatial data, helping identify patterns and structures within imagery. This is beneficial for tasks such as vegetation analysis, geological mapping, and urban planning.

4. **Change Detection:** Deep learning models can be applied to detect changes in land cover, infrastructure, or other features over time. This is crucial for monitoring urban expansion, deforestation, and environmental changes.



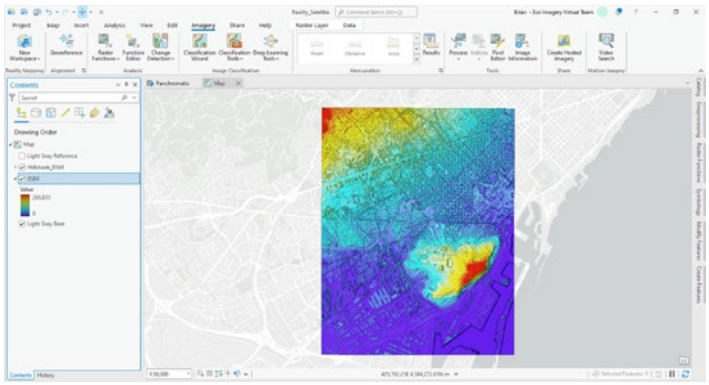


5. **Land Use and Land Cover Analysis:** Deep learning aids in the analysis of land use and land cover by automatically classifying different types of land features in satellite or aerial imagery. This information is valuable for urban planning, agriculture, and environmental studies.



ArcGIS Reality for Pro 3.2

With the latest release of ArcGIS Reality for ArcGIS Pro, reality mapping just got bigger, and there are no limits on the scale – and possibilities – of your reality mapping projects. Now, you can use readily available RPC satellite imagery to create highly realistic representations of virtually anywhere on Earth, and within the familiar ArcGIS Pro environment.



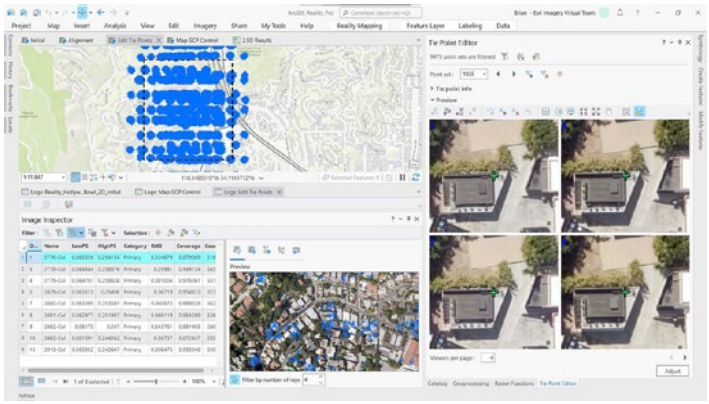
RPC Satellite imagery in Reality

Reality mapping with RPC satellite imagery allows you to create digital representations that are incredibly true-to-life and accurate, providing a powerful tool for gaining deeper insights and understanding of any region of interest, regardless of its size or location. You can further enhance your ability to visualize, analyze, and understand large or remote regions of interest by leveraging the powerful analysis tools that already exist in ArcGIS, such as change detection, multidimensional analysis, line-of-sight tests, viewshed analysis, and other AI-powered functionalities.

Advantages of adding reality mapping to your GIS workflow

Gain insights into remote areas

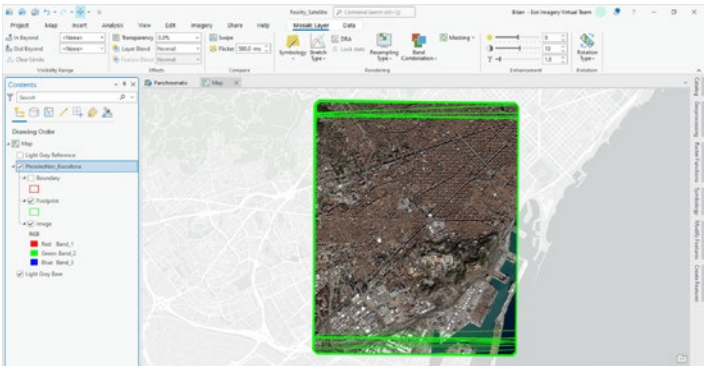
The incorporation of reality mapping into your GIS, connects the digital and real world, empowering you to make informed decisions. It allows you to accurately assess the extent of damage caused by natural disasters, detect invasive species, or map deforestation even when you are physically distant from the location.



Reduce your risk

Reality mapping with RPC satellite imagery provides a safe and efficient alternative for data collection and analysis. It allows for remote assessment of the environment, identification of potential risks, and informed decision-making, all while reducing the risk to human lives and expensive equipment. This is particularly beneficial when

dealing with active disaster zones and conflict areas or assessing recent conditions in remote regions with challenging terrain.

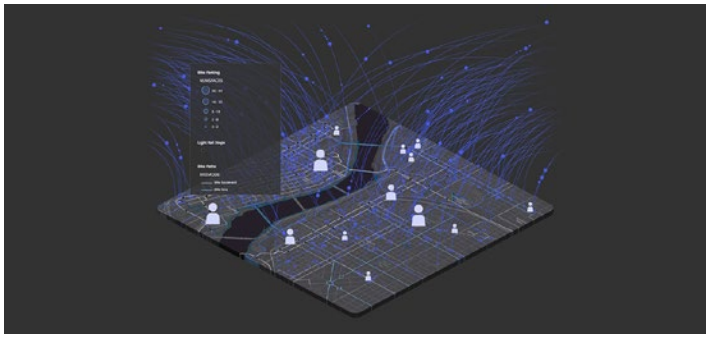


Make better decisions about large areas of interest, faster

Now, with the support for satellite imagery, you can leverage the unique ability of satellites to quickly capture data of virtually any area of interest in the world. Leveraging satellite imagery for reality mapping extends its value by adding an additional dimension that enhances insights, awareness, and potential. This additional perspective enhances the analytical capabilities and provides valuable information for time-sensitive decision-making in applications such as disaster response and management and security and defence.

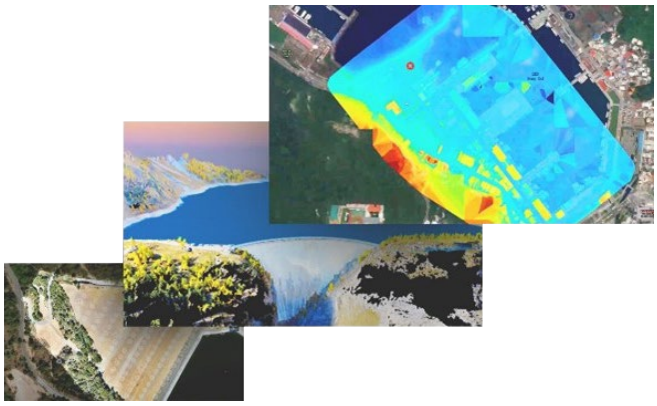
Beyond satellite support: More ways ArcGIS has enhanced reality mapping

Satellite support isn't the only exciting new capability in ArcGIS Reality for ArcGIS Pro. The latest release also enhances functionality to accommodate various data inputs and storage locations. These updates enable users to seamlessly integrate different types of data and work with their preferred data storage systems, providing a more flexible and efficient workflow for reality mapping.



Access your data in the cloud

Now, you can use imagery stored in AWS, Azure, and enterprise object stores for reality mapping thanks to the latest release of ArcGIS Reality for ArcGIS Pro. You're no longer limited to the storage constraints of local disks or network folders. By leveraging the cloud, you can reduce the overhead cost of maintaining your own storage infrastructure or use your own cloud management environment to create easy access to the reality mapping inputs you need, when you need them.



Support for rolling shutter cameras

With the latest release of ArcGIS Reality for ArcGIS Pro, you can generate high-quality 3D meshes and other reality mapping products from drone images captured using rolling shutter cameras. You'll now get more accurate alignment results for images captured using rolling shutter cameras. The higher quality alignment results increase the accuracy and overall correctness of the DSMs, True Orthos, Point Clouds, and 3D Meshes.

AMITY UNIVERSITY
UTTAR PRADESH

Nurturing the Next Generation of Geospatial Leaders

Dr. Maya Kumari
Assistant Professor, AIGIRS

Dr. Varun Narayan Mishra
Assistant Professor,
AIGIRS

Amity Institute of Geo-Informatics and Remote Sensing (AIGIRS) is an interdisciplinary center, established as a part of Amity University Uttar Pradesh, Noida. With the objective to inculcate geospatial skills in students and make them job-ready, it offers undergraduate, postgraduate, and doctoral programs in Geoinformatics. These programs combine technical, mathematical, computational, and visual knowledge and offer the students the possibility to not only use geoinformatics technology but also develop and create new computational methods and applications. In addition to gaining an overall perspective, students can further focus their skills on one of the subjects within geoinformatics, such as geodesy, photogrammetry, laser scanning, remote sensing, geographic information technologies, or cartography.

To explore AIGIRS' initiatives to develop academic capabilities, problem-solving skills, and geospatial thinking capabilities of students, and understand how Esri India is enabling this, we had an interaction with **Dr. Maya Kumari, Assistant Professor and Dr. Varun Narayan Mishra, Assistant Professor, AIGIRS.**

How has the adoption of geospatial technologies evolved over the years in various industries? Are we witnessing higher usage? Why is this happening?

In recent years, the adoption of geospatial technologies has undergone a transformative journey across various industries, witnessing a remarkable surge in usage. This paradigm shift is driven by a convergence of technological advancements, increased data availability, and a growing recognition of the profound impact geospatial insights can have on decision-making processes. Over the years, geospatial technologies have experienced significant advancements in terms of AI/ML, deep learning, and Internet of Things (IoT). These improvements have not only enhanced the precision and accuracy of spatial data but have also made these technologies more accessible and user-friendly towards achieving SDGs. As a result, industries are finding it increasingly feasible to integrate geospatial tools into their workflows. Furthermore, the decreasing costs associated with geospatial technologies, spanning hardware, software, and data acquisition, have played a pivotal role in fueling their widespread adoption.

> "Nowadays, geospatial technologies have seamlessly integrated with other cutting-edge technologies, such as artificial intelligence, machine learning, and the Internet of Things (IoT). This integration amplifies the capabilities of geospatial tools, allowing industries to extract more sophisticated insights from spatial data and enhancing overall operational efficiency."

The geospatial revolution is underway, and its impact is reverberating across industries, shaping the future of decision-making and resource management. In recent years, exploring and analyzing spatial data through various tools and techniques has strengthened traditional data science. Understanding more about the spatial data means more than location-based coordinates and that location-based context reveals hidden patterns in real-world data. Prediction is a fundamental function of data science. Currently, there is an emergence in the field of simulation and prediction of real-world scenarios by incorporating spatial properties into modeling workflows. It expands our understanding of data and enhances spatial predictive power. Also, the automated process of detecting objects and identifying land surface features from imagery is gaining a lot of interest in the current time.

With an increase in use, there is a rising demand for a geospatially skilled workforce in the country. How are academic institutes like Amity helping in bridging this gap?

In the rapidly evolving landscape of technology, the demand for geospatially skilled professionals has surged, echoing the increasing reliance of industries on spatial data insights. Recognizing this growing need, academic institutions like Amity University are playing a pivotal role in shaping a geospatially competent workforce that meets the demands of the contemporary world. Amity University is actively bridging the talent gap and preparing students for impactful careers in the geospatial domain. Amity University, in alignment with the industry's demands, has taken strides and offers two postgraduate programs (M.Sc. and MTech. in GIS and Remote Sensing) and one

Undergraduate program (B.Sc. Geoinformatics).

Amity's commitment to offering a comprehensive curriculum ensures that students are exposed to geospatial tools, enabling them to navigate the multifaceted challenges posed by contemporary industries. To empower students with hands-on experience, Amity University invests in state-of-the-art infrastructure and well-equipped geospatial laboratories. The courses offered by Amity University attract students who want to learn how the special capabilities of spatial data analysis provide a deeper understanding of real-world scenarios and associated challenges of climate change, global warming, and environmental degradation. **The hands-on experience gained in the labs ensures that graduates are not only theoretically grounded but also possess the practical skills required by employers in the geospatial sector.** Collaboration with industry leaders and experts is a cornerstone of Amity's approach to preparing students for the workforce. Through partnerships with geospatial technology companies, students gain valuable insights through workshops, seminars, and guest lectures. This collaboration not only provides students with exposure to the latest industry trends but also helps them build a professional network before entering the workforce.

Academic institutions like Amity University are at the forefront of nurturing the next generation of geospatial leaders. By aligning their educational strategies with industry needs, providing hands-on experience, fostering collaboration, and emphasizing continuous learning, these institutions are actively contributing to bridging the talent gap in the geospatial sector. As the demand for geospatially skilled professionals continues to rise, institutions that prioritize holistic and industry-relevant education will undoubtedly play a pivotal role in shaping the future of the geospatial workforce.

How is the collaboration with Esri India helping Amity in this endeavor?

In the dynamic realm of geospatial technologies, collaboration between academia and industry leaders is paramount for preparing students to meet the evolving demands of the workforce. Amity University, a proponent in academic excellence, has embarked on a transformative journey by establishing a collaborative partnership with Esri India, a leading provider of Geographic Information System (GIS) solutions.

> "The collaboration between Amity University and Esri India brings cutting-edge geospatial technologies directly into the hands of students. Esri's GIS software suite, renowned for its industry-standard tools, becomes an integral part of the learning experience. Through this collaboration, students gain hands-on exposure to state-of-the-art GIS applications, empowering them with the practical skills required in real-world scenarios."

The collaboration facilitates the infusion of industry relevance into Amity's geospatial curriculum. Esri India's expertise contributes to the continuous improvement of course content, ensuring that it aligns with the latest advancements and industry requirements. This dynamic approach to curriculum enhancement not only keeps students abreast of the rapidly evolving geospatial landscape but also enhances their employability upon graduation. Esri India's collaboration with Amity extends beyond the classroom, offering students valuable internship opportunities. Through hands-on projects, students gain practical exposure to real-world challenges faced by industries leveraging geospatial technologies. These internships not only supplement theoretical knowledge but also serve as a bridge between academic learning and professional application. **The collaboration between Amity University and Esri India is a testament to the transformative potential of partnerships between academia and industry leaders.** By combining academic rigor with industry insights, this collaboration not only enhances the educational experience for students but also contributes to the development of a geospatially skilled workforce ready to tackle the challenges of the future.

What are the trends you are witnessing in the employability of geospatially skilled students?

The employability of geospatially skilled students is becoming increasingly valuable in today's job market. With the growing importance of data analysis and mapping technologies in various industries, employers are seeking individuals who possess the knowledge and expertise in geospatial technologies. The increasing reliance on technology and data-driven decision-making has created a high demand for professionals who can effectively utilize geospatial technologies. The ability to collect and analyze spatial data allows organizations to make informed decisions and optimize resource allocation. Moreover, with the growing emphasis on sustainability individuals with geospatial skills are crucial in navigating the challenges of an increasingly complex and interconnected world. **The diversification of geospatial job opportunities has created a demand for professionals with specialized skills in areas such as geospatial analysis, remote sensing, and GIS development. With the expansion of the geospatial industry beyond traditional GIS roles, there are now more opportunities for individuals to pursue careers in geospatial technology and contribute to various sectors such as urban planning, environmental management, and transportation.**

The emergence of new job titles like geospatial analyst, remote sensing specialist, and GIS developer reflects the evolving nature of the geospatial field and the need for individuals with specific expertise in utilizing geospatial technologies.

If we particularly talk about the infrastructure sector, how is GIS enabling the sector to perform better? Do we need engineers of today to be equipped with geospatial skills to increase employability as well as achieve better outcomes in their future projects?

In the ever-evolving landscape of infrastructure development, GIS technology has emerged as a game-changer, fostering innovation, efficiency, and informed decision-making. As we navigate the complexities of modern engineering projects, the integration of GIS into the infrastructure sector is proving to be a transformative force on the following points:

1. **Optimizing Site Selection and Planning:** GIS provides a powerful toolkit for engineers in the initial stages of infrastructure projects, aiding in site selection and planning. By analyzing spatial data related to topography, land use, and environmental factors, engineers can make informed decisions about optimal project locations. This capability ensures that projects are strategically positioned to maximize efficiency and minimize environmental impact.

2. **Enhanced Asset Management:** Effective asset management is a cornerstone of successful infrastructure projects. GIS facilitates comprehensive inventory management by allowing engineers to create detailed databases of infrastructure assets. From roads and bridges to utilities and public facilities, GIS enables engineers to monitor the condition, performance, and maintenance needs of assets, ensuring longevity and operational efficiency.

3. **Spatial Analysis for Decision Support:** GIS serves as a powerful decision support system by enabling engineers to conduct spatial analyses. This includes evaluating the impact of proposed projects on the surrounding environment, assessing risk factors, and optimizing resource allocation. The ability to visualize and analyze spatial data empowers engineers to make well-informed decisions that align with both project goals and environmental sustainability.

4. **Environmental Impact Assessment:** The infrastructure sector is under increasing scrutiny for its environmental footprint. GIS plays a pivotal role in conducting thorough environmental impact assessments. Engineers can analyze spatial data to understand how projects may affect ecosystems, water bodies, and air quality. This insight is invaluable for developing mitigation strategies and ensuring compliance with environmental regulations.

5. **Emerging trend of Disaster Risk Reduction and Resilience Building:** Further the existing roles or processes by the government agencies and local communities, emerging trends of disaster risk reduction and resilience building demand technological developments to provide valuable insights and evidence-based solutions for improving the potential of community-based disaster preparedness initiatives, response, and recovery efforts. Innovations in technology like AI/ML, big data, IoT coupled with RS and GIS contributing towards the collection of spatial data, management, and community engagement have wider potential in solving various disaster-related issues.

6. **Smart Cities and Urban Planning:** As urbanization accelerates, GIS becomes instrumental in smart city initiatives and urban planning. Engineers leverage GIS to analyze population density, traffic patterns, and infrastructure needs. This spatial intelligence aids in designing efficient transportation systems, optimizing urban layouts, and implementing sustainable infrastructure solutions for evolving cityscapes.

GIS and other emerging techniques are a catalyst for positive change in the infrastructure industry, offering a comprehensive set of tools to enhance decision-making, optimize project outcomes, and ensure sustainable development. The integration of geospatial skills into the skill set of today's engineers is a strategic imperative, aligning with the industry's shift towards data-driven, technology-enabled solutions.

Optimal Siting of Charging Infrastructure for EV Ecosystem Partners: A Multi-constraint Approach integrated with Geospatial Analysis

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Abstract:

Electric mobility is one of the key drivers of the undergoing clean energy transition. As the primary enabler of sustainable transportation, electric mobility plays a critical role in achieving net-zero carbon emissions. The availability and optimal access to Electric Vehicle (EV) charging infrastructure plays a critical role in accelerating the EV adoption goals set by various countries and regions. Hence, the planning for the optimal location of EV charging station setup is crucial for various partners – Customers, Charge Point Operators (CPOs), Original Equipment Manufacturers (OEMs), and Utility grid operators in the EV ecosystem defined below:

- **Customers:** People who own and use EVs for transportation
- **Charge Point Operators (CPOs):** Entities that provide charging services to EV customers
- **Original Equipment Manufacturers (OEMs) :** Manufacturers of charging stations as well as EVs
- **Utility grid operator:** Entities that operate power grids and support EV charging stations

As urban areas deal with space shortages, and energy demands are rising exponentially, identifying suitable and appropriate locations for setting up charging stations is a challenge. Both supply side and demand side inputs are important to arrive at the optimal location of charging stations. The supply side input datasets include - EV fleet growth forecast from OEMs, current utilization rate and fleet availability from CPOs, and power grid constraints from Utility grid operators. Demand side input datasets include – EV travel patterns and customer behavior. These data sets will be processed and transformed into geospatial data layers to be overlaid on a base layer that represents the area of study. Supply-side constraints, relating to CPOs, Utility grid operators, and OEMs, include proximity to electric infrastructure and public space availability. The stakeholder constraints on the demand side include customer travel range and pattern which will be captured in the traffic density data layer. Accordingly, these inputs and constraints will be processed in a geographical information system (GIS) to determine the optimal location of EV charging stations in a particular region. A ranking-based framework scrutinizes suitable sites among the feasible ones and the rank is decided based on the total score obtained by each candidate site. The results of such analysis will ensure that the stations are optimally located near the customers, the Utility power grid is not overloaded, and the CPOs obtain maximum revenue from their charging business while the OEMs can plan their manufacturing output based on the demand pattern.

Introduction

Environmental concerns owing to the usage of fossil fuels have led to serious actions towards safeguarding the ecological and economic balance. Global greenhouse gas emissions due to energy usage and transportation have catapulted the shift towards sustainable alternatives in the form of the undergoing energy transition. Energy and power systems are moving towards cleaner Renewable Energy (RE) sources, both centralized utility-scale power plants and microgrids while energy efficiency and increasing consumer participation (in the form of prosumers) are gaining importance at the consumer end. Transportation is also moving away from fossil fuel-powered vehicles to their sustainable alternatives and electric mobility is emerging as the strongest amongst them. Electric Vehicles (EVs) have an all-electric drive train powered by a battery while gasoline-electric hybrids also exist. Having a robust EV charging infrastructure is the main requirement for establishing a comprehensive E-mobility ecosystem.

Random allocation of spots for installing EV charging stations is not a sustainable practice since demand growths are sporadic and the electricity distribution infrastructure also needs to be revamped accordingly. Moreover, **as cities expand and urbanization and commercialization grow exponentially, finding adequate space for installing the EV charging station system setup is the biggest challenge.** Hence, a more scientific approach is required to site public EV charging stations in an urban area which can also be treated as an optimization problem that needs to follow the various constraints relating to an urban setup. Many methods have been documented in the literature[1] for finding the optimal location of public EV charging stations in urban areas/cities for both intra-city and inter-city travel. Many of these approaches consider the problem from the point of view of an electrical power distribution network wherein the most appropriate node on the distribution network is identified to site EV charging stations. However, it has been found that practically, often the node suggested by the optimization problem solver turns out to be in a physical area where space for setting up a public EV charging station is not adequate. It is thus important to view the problem from a geospatial angle wherein the actual grounds-up approach can be adopted considering each aspect: land usage, traffic movement, electricity distribution infrastructure, proximity to road/highway network, and many such factors. **In this paper, a geospatial analysis has been described in the form of a framework approach that can be adopted to optimally site public EV charging stations in city areas considering multiple constraints relating to the key stakeholders or ecosystem partners in the E-mobility domain.**

Key Input Datasets

The key stakeholders in the E-mobility eco-system are namely:

1. Customers or EV owners having different purposes (residential for office commute, commercial, logistics, etc.)
2. Charge Point Operators (CPOs): Entities that install and operate the EV charging stations
3. Original Equipment Manufacturers (OEMs): For both EVs and EV chargers
4. Utility power grid operators

Apart from these, there are electric fleet operators too that are becoming important for intra-city passenger commute or inter-city travel as well as for logistics. However, from the point of view of the availability of datasets as important decision variables in the geospatial domain, the above four stakeholder categories hold good. Public EV charging stations are akin to diesel or gasoline refueling stations for Internal Combustion Engine (ICE) vehicles although the battery charging time or 'refueling' time is longer than that for the gas stations. However, battery swapping stations are also emerging as a smarter alternative wherein the exhausted vehicle battery is replaced by a fully charged one, there are compatibility and inter-operability issues with battery and vehicle brands. EV charging stations are characterized by charging power and voltage levels. For intra-city travel, AC or slow or level 1 chargers spread across the city's important points or junctions can support the travel needs for a limited distance within the periphery of the city. For such chargers, average output powers start from 3.3 kW upto 10 kW although in some countries, even 15 kW is considered as fast charger. For inter-city travel, fast or DC chargers are important as they can provide quicker charging times to fully charge batteries of vehicles that need to cover long distances on highways. Intra-city chargers placed at commercial places like shopping malls or cinema halls also provide revenue-earning avenues for CPOs through opportunity charging wherein customers can have their parked vehicles charged at competitive rates while shopping or grabbing a cup of coffee or watching a movie.

It is thus crucial to lay down a network of EV charging stations (fast or slow) that are strategically placed at important junctions of the city or at strategic points along the highway. To support the demand for the charging of vehicles which, in turn, is dictated by travel patterns and customer behavior, a strong and robust electricity supply infrastructure is necessary. Accordingly, input datasets both from the demand and supply sides are important to identify to create the geospatial layers. Numeric values in these datasets are translated or extracted into geospatial layers to perform the geospatial analysis for the siting of EV charging stations.

The important datasets from the supply side include the following:

- Existing EV charging stations in the city/region of study
- Electricity supply infrastructure/network
- Street and road network

The important datasets from the demand side include the following:

- Vehicle population density
- EV travel pattern/customer behavior

The datasets listed above need to be transformed into geospatial datasets for performing the analysis. The directly available geospatial datasets that are required for the analysis include:

- Land Use/Land Cover
- Population density
- Traffic density

Considering each stakeholder, datasets specific to them are:

- EV growth forecast numbers – available from OEMs
- Current EV fleet utilization rate – available from CPOs

Some policy and regulatory level information or data may also be useful to consider as an input variable for planning the optimal siting of EV charging stations using geospatial analysis.

EV Charging Station Siting Key Considerations

Public charging stations must cater to the charging demands based on the travel patterns and customer charging behavior and must be located optimally to serve the traffic at important junctions of the city for example near airports, major roadway points or at commercial centres. The key points to consider while optimally siting EV charging stations can be taken as constraints in the optimization problem having key inputs embedded in the form of decision variables. To understand customer behavior and capture it in the form of key decision variables or constraints, a survey can be performed in case digital records for a location are not available. Some of these data points include:

- Average time to stay
- Parking space availability
- Proximity to road/highway

Figure 1 shows the key datasets and the sources from where they can be collected. To highlight the relative importance of each of these parameters in deciding the location of an EV charging station, weights have been assigned to each variable as shown in Fig. 1. For example, proximity to the road or nearness to the electricity infrastructure must be relatively high while the average time to stay can be average medium or high to help rank the site as a potential EV charging station location. The weights assigned to each of such parameters based on domain-level judgement are accumulated in the optimization problem that is fed to the GIS solver engine. The flow is shown in the figure.

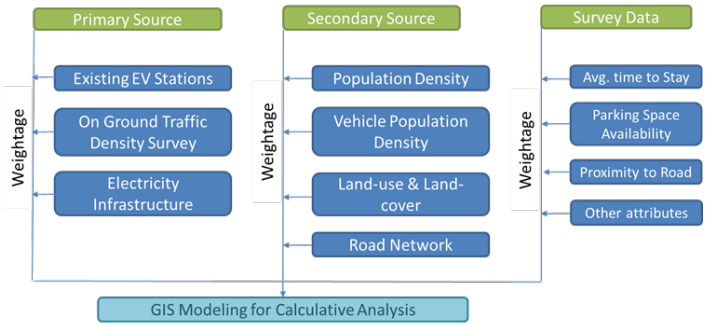

Fig: 1 – Datasets and their sources

For a site to become an optimal location for an EV charging station, some of the considerations that need to be taken into account are:

- Proximity to nearest electricity distribution sub-station/distribution transformer must be high
- Nearest electricity network infra must be strong and robust having enough capacity to support EV charging load
- Enough space for setting up the charging infrastructure must be available
- Density of vehicles passing through the site must be high

These high-level considerations can then be incorporated into a numeric framework which can be fed into a GIS analysis engine running the geo-spatial analysis to find out the most optimal EV charging station's location.

Methodology and Framework

There can be a number of potential sites in a city or a region where EV charging stations can be located. This site-suitability analysis can be carried out at a geospatial level in a GIS framework to optimally arrive at the best among the suitable candidate sites. The relative weights assigned to each of the important parameters can be used in the GIS optimization framework so that the actual geographical co-ordinates can be identified after the optimization problem has been solved considering the constraints and the decision variables (both having weights assigned) The result of the GIS analysis is a rank assigned for each site which is obtained based on a site-suitability score. The site-suitability score is generally arrived at based on the degree of match with the desired constraints as explained above – high proximity to electricity infrastructure, high space availability, etc.

Figure 2 shows the methodology of site-suitability analysis which considers the inputs and constraints related to all the four stakeholders: Users/EV customers, CPOs, OEMs and power grid operators.

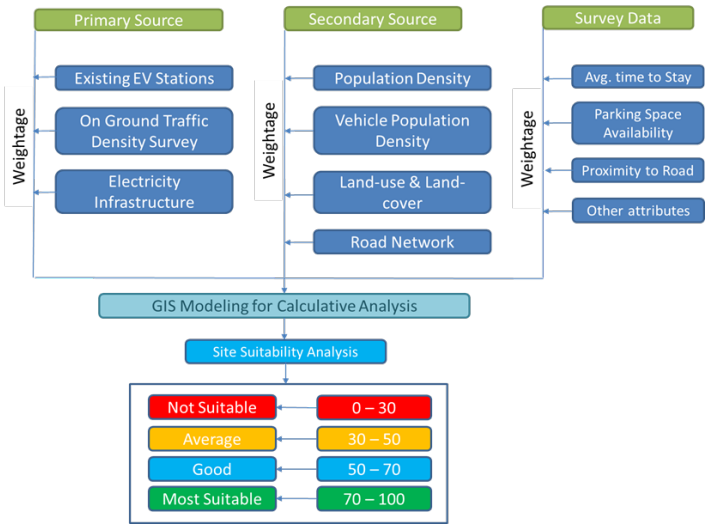

Fig: 2 – Site suitability analysis

Figure 3 shows a sample digital map form where multiple datasets in the geospatial domain can be extracted. These datasets and the survey datasets can be used together to run the geospatial location finding analysis based on the internal distance based optimization algorithm [2].

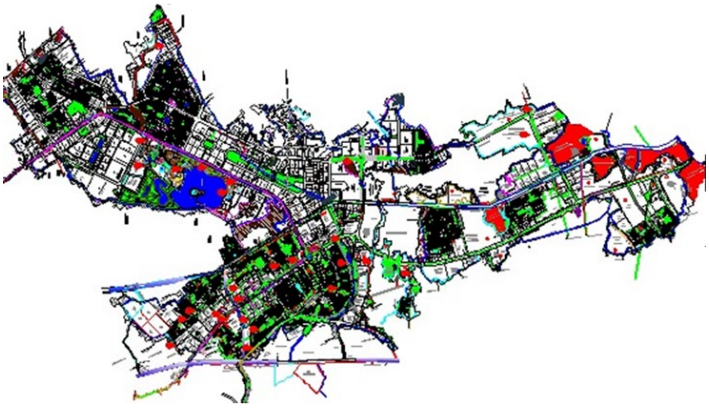

Fig: 3 –City area digital map for analysis
Source: www.wbhidcoltd.com

The various data layers that can be extracted from the above digital map include:

- Land Use/ Land Cover
- Points of Interest (landmarks in the city)
- Roads
- Building Footprints

Based on the ranking score obtained for each candidate site, the sites with the highest ranks can be considered as the most suitable locations for siting public EV charging stations. Figure 4 shows a sample map of the same region with the most suitable sites identified by the analysis engine as red colored spots.

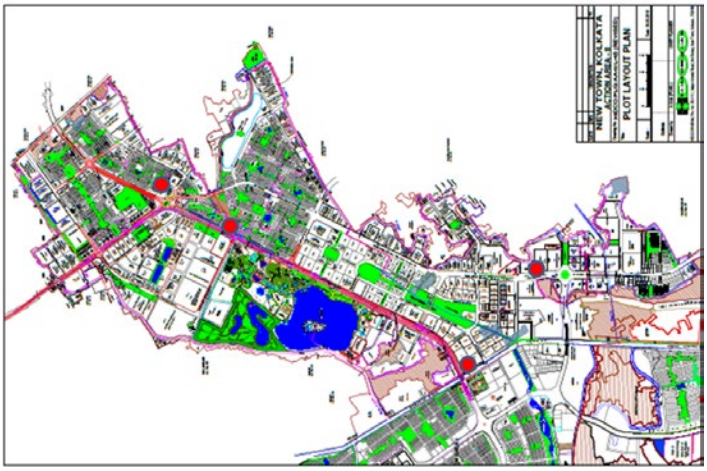

Fig: 4 –City area map showing four most suitable sites (in red)
Source: www.wbhidcoltd.com

Conclusion

In this paper, a multi-constraint framework using GIS analysis has been proposed to determine the optimal locations of public EV charging stations. The various key input datasets, both from the supply and demand side and different constraints have been identified and discussed. The methodology of transforming each of these datasets into geospatial data points and assigning weights to them in order of relative importance has been presented. The final step of obtaining scores to rank the potential candidate sites has been described. A sample illustrative digital map of a region of a city is shown with the optimal or most suitable sites identified. The key stakeholders in the E-mobility domain that are considered for this study are: Customers/EV users, OEMs, CPOs and utility-grid operators. From the point of view of locating public EV charging stations in urban areas, these are the important entities to consider. As the e-mobility landscape evolves, more players will emerge.

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Acknowledgement

WBHIDCO for the availability of geospatial maps on their public websites.

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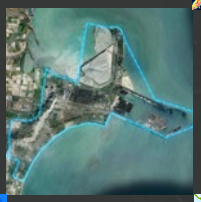

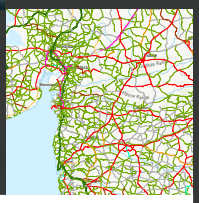

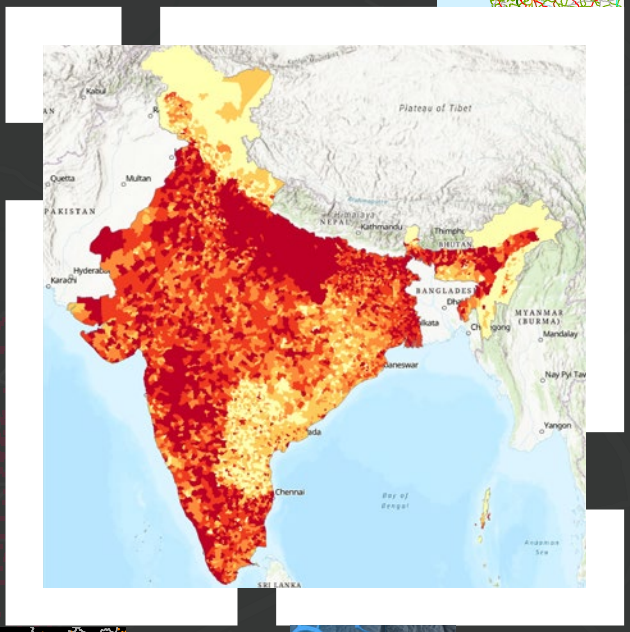

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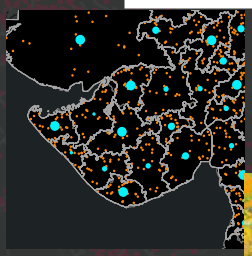

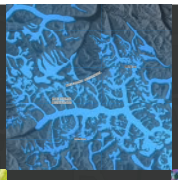

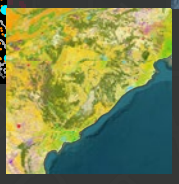

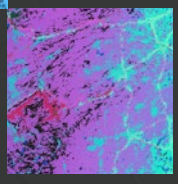

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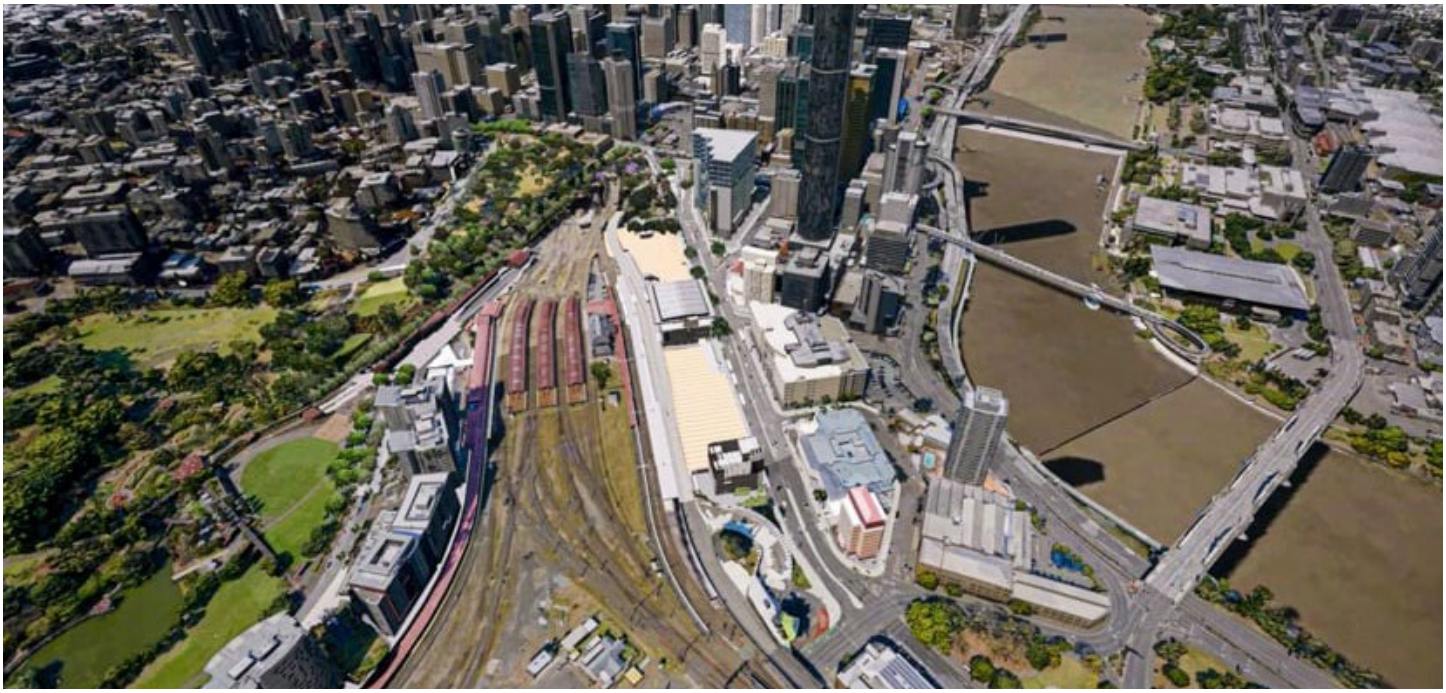


In Australia's Fastest-Growing City, a Digital Twin Guides Rail Expansion

By Terry Bills and Ian Koeppel

In Brisbane, the most rapidly growing city in Australia, a digital twin and a virtual reality program guide the design and construction of an underground railway.

Key Takeaways

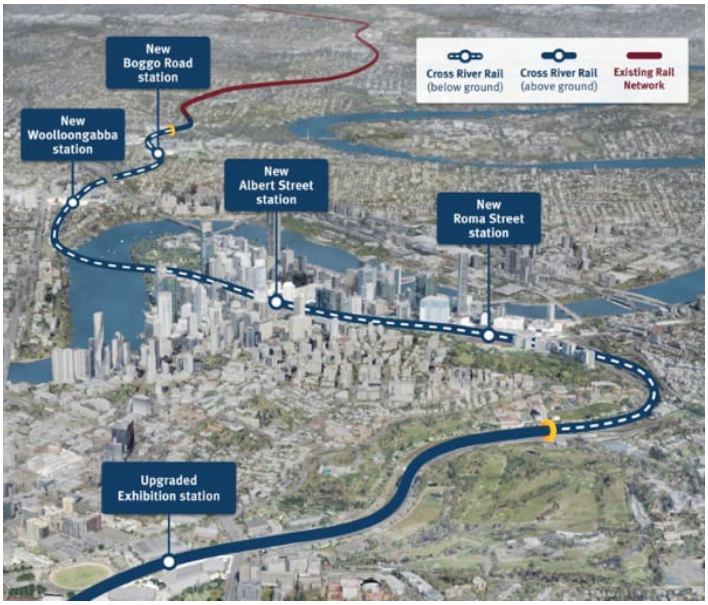
- In Brisbane, Australia, an evolving digital twin is helping teams design and build the underground Cross River Rail project, the city's first subway.
- Engineers and designers use a central repository to integrate all data related to the new tunnels and stations, married to a realistic model of the city above.
- A game engine transforms the twin into a virtual reality tool to walk through designs, plan complicated construction, and communicate progress.

The team tasked with designing the first underground railway under the heart of Australia's fastest-growing city knew it would be a delicate task, fraught with infrastructural peril. Tunneling several stories under Brisbane's teeming metropolis, constructing expansive subterranean stations—what could go wrong?

With the scheduled completion less than two years away, it's clear they made strong choices. But at the outset, nobody knew that the effort would involve an ingenious application of a geographic information system (GIS), creating a detailed and up-to-date 3D model of the project and the Queensland capital city above it, and an immersive digital twin that brings the project to life.

A Rapidly Growing Queensland

The Queensland government conceived the Cross River Rail project as a way to alleviate population pressures. By 2036, the South East Queensland metro area is projected to add another 1.5 million residents (a number that by itself would make it Australia's fifth-largest city), pushing the region's total population to nearly 5 million.



The Cross River Rail project will deliver a new 10.2km line through Brisbane's inner city, featuring twin 5.9 km tunnels running under the Brisbane River and CBD. Four new underground stations will be built as part of the $5.4b project, in addition to the upgrade of eight existing stations.

Most of these new arrivals will live outside of Brisbane, but within commuting distance. Many of the new jobs, however, will be in the Brisbane CBD (central business district), on the north bank of the Brisbane River.

Current rail infrastructure is insufficient to handle the necessary increase in CBD-bound train traffic. Cross River Rail will add 6 kilometers of twin tunnels under the river and four new underground stations.

A Bigger, Better Model

Soon after the project was announced, the Cross River Rail Delivery Authority, the overseeing agency created by the Queensland government, sought advice from colleagues on the other side of the world. The Crossrail project in London, launched in 2009, has similar aims, creating new tunnels and ten new underground stations throughout Central London.

Crossrail involves construction beneath a metro area even denser than Brisbane's, with extremely narrow margins to avoid damaging existing underground infrastructure. "They're like our big brother that we idolize," said Russell Vine, Cross River's chief innovation officer.

By the time Cross River's plans were beginning, Crossrail had been under construction for almost seven years. The Cross River team contacted their British counterparts and asked what, if anything, they would do differently if they could start over.

"They basically said, 'we would have built a bigger, better 3D digital model sooner,'" Vine said. The big brother then offered three steps for how to build the perfect GIS-driven digital twin:

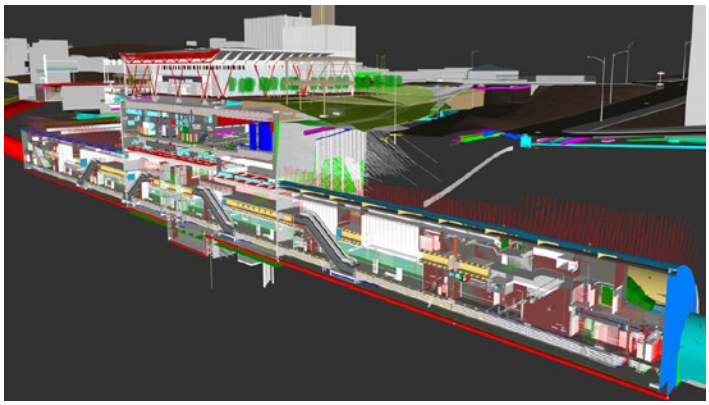
- Create a common data environment
- Stipulate that all contractors use the same standards in their 3D architectural models, so that they can all combine into a single model for the project
- Make the model immersive

An Expansive Mission

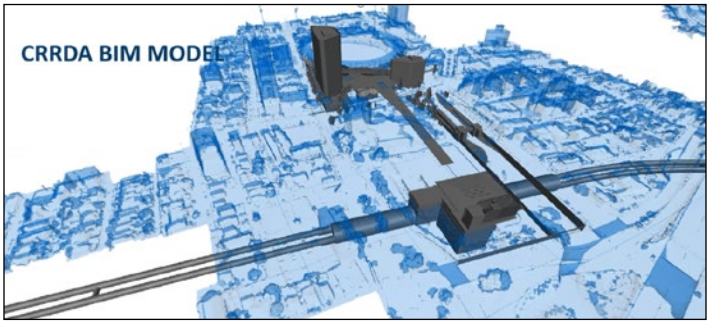
For starters, Crossrail recommended that Cross River create a common data environment for all work. Any project-related dataset, no matter what the format—GIS, building information modeling (BIM), volumetric, photogrammetry (a three-dimensional coordinate measuring technique that uses photographs), everything—should be in a central repository.

This was useful advice. In recent years, GIS technology has become adept at integrating BIM models and other project-related data formats into a GIS environment.

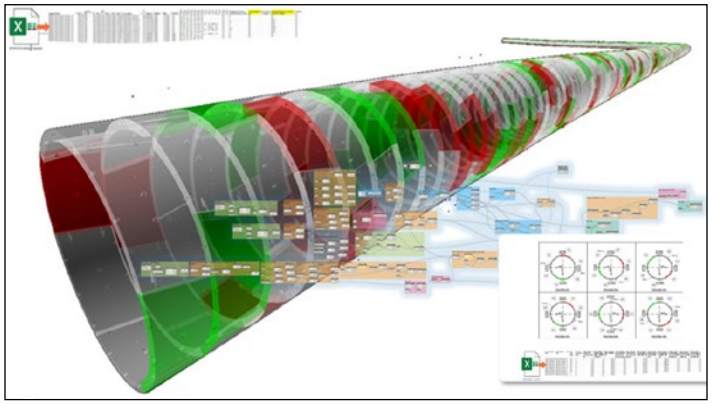
BIM models are 3D architectural models. They describe and depict the actual things being built or dug, while GIS adds contextual awareness.



A BIM model of Wgabba Station shows the level of detail required to guide construction.



A federated BIM model for Cross River Rail brings together project-wide details for the whole project.



For tunnel work, the components and sequencing of parts requires close tracking.

Rather than just consider the BIM models as inert objects floating in space, people involved in a project can visualize what's around them. In GIS they can see how each structure fits into the infrastructure above ground (such as paths, roads, and light poles), underground (the pipes and lines that connect utility services) and to the natural world (landscaping, groundwater, and even wildlife and biodiversity considerations).

The advice also helped Cross River handle a broad mandate. When Queensland's government created the Cross River Rail Delivery Authority, it required the agency to be responsible not just for the railway itself, but also for planning and assessing the project's economic impact.

There was a good reason to include this mandate in the agency's charter. Although Cross River's aim anticipates future developments in the region, its location means Cross River will also influence those developments.

"Cross River Rail is going right under the CBD, so the area around the stations is already prime land where the city will grow next," Vine said.

Everything In Federation

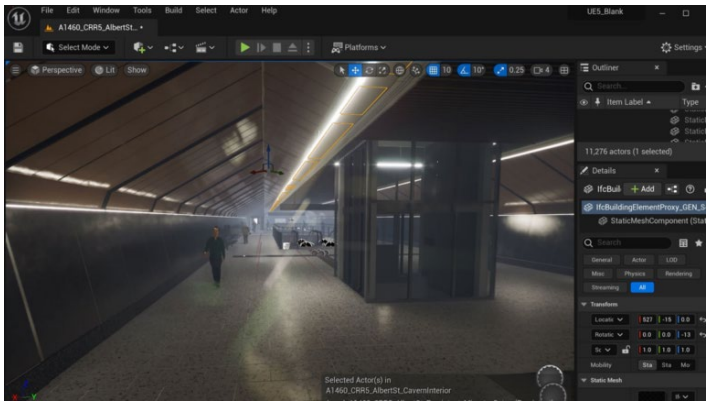
Crossrail's second piece of advice related to BIM data coming from the project's many contractors and subcontractors. Create a "federated" BIM model, the Brits advised.

That meant combining the disparate BIM information into a single BIM file that depicts everything. For that to happen, Cross River needed to ensure that every contracting entity was using exactly the same data formats, standards, and protocols.

"What the Crossrail team didn't realize until it was too late is that all their contractors were telling Crossrail how they were going to submit their BIM models—it was baked into the contracts," Vine said. "They told us, 'we indulged them, and we shouldn't have.'"

Rail Games

Crossrail's third recommendation is "the party piece, the one everybody loves," Vine said, because it's about making the model immersive. "They told us they should've put all their data into a game engine and turned it into virtual reality."



Putting BIM models into Unreal Engine allows engineers and other stakeholders to experience each station before they build it.

The Australian team did just that, using Unreal Engine, a 3D gaming tool, to tie it all together, so anyone sitting anywhere could be transported inside the place they were set to build.

"So we have a federated BIM model of all the stations and all the tunnels, and GIS land mapping in 3D," Vine said. "But then we put it all into Unreal, crank the magic gaming engine handle, and it gives us back a single virtual reality."

The result is 17 kilometers of immersive railway infrastructure that can be explored, like a first-person game, on a screen manipulating a web scene or with a virtual reality (VR) headset. The Cross River team even built a virtual reality theater using a five-way projection system, so that many people can explore the project together.

The virtual reality component transcends mere flash, providing a way for non-technical stakeholders—people not directly involved in the design and construction of Cross River—to view the project as it proceeds. It also gives those who are part of the design team the kind of visual assessments that even the most detailed 3D BIM model cannot provide. As one example, Vine points to the Roma Street station, where teams are experimenting with ways to install a massive art exhibition space on a concourse wall, trying and testing different ideas virtually before they finalize the design and build it.

The Digital Twin Expands to Capture All of Brisbane

Cross River's commitment to the common data environment (step

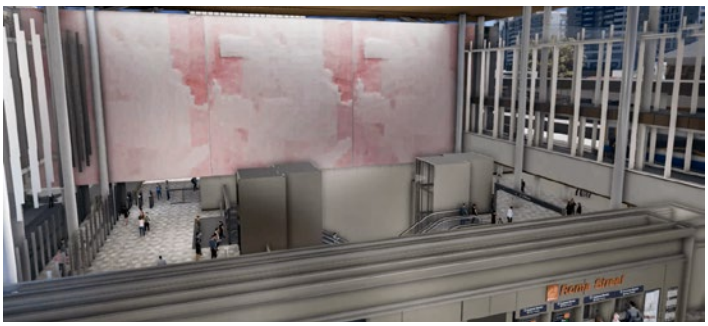
one of the three-point plan recommended by the Brits) signaled a shift in the usual relationship between GIS and BIM on this kind of large infrastructure project. In the past, GIS for sure would have served as a crucial support player, a context-adding host for the 3D architectural BIM renderings. But given the mandate to document economic development around the train stations, Cross River elevated the importance of GIS. To depict those above-ground areas, Cross River would require skillful 3D maps, including data gathered by Lidar sensors to capture engineering-grade measurements.

That, in turn, led to another requirement. The above-ground data would also require context.

If the goal was to understand how the stations would affect economic development in the CBD, it didn't make sense to map just the area around them. You needed a map of the entire CBD. And everything would need to be layered perfectly, so that anything underground (stations, tracks, tunnels, cables, and pipes) lined up in every respect with what was above it.

The Roma Street cavern shows the complexity of the two-tunnel subway line.

Workers enter the Roma Street cavern to conduct and inspection.



This model of the aboveground element of Roma Street Station shows the colossal art wall that will be a prominent feature of the station.

The result is a 3D land layer that shows lots, utilities, and other pertinent visual information. Cross River's use of 3D even includes material designed in consultation with Brett Leavy, a self-described "cultural heritage digital Jedi" who uses advanced VR technology to recreate pre-colonial Brisbane. Leavy's input, Vine explained, has helped ensure that the project honors and remains respectful of a First Nations perspective.

"We went from 'it's all about building a railway' to 'ah, it's also about rebuilding the city,'" he said. "We ended up making a 3D model of Brisbane, because it was impossible to do one without doing the other."

A Twin Without End

The Cross River digital twin is a continuous work in progress. As designs are finalized and construction proceeds, a staircase or tunnel that existed as a single item in a contractor's initial BIM submission becomes one with thousands of individual components in the federated BIM model.

Beyond just the Cross River project, there's no reason the digital twin can't continue to grow in perpetuity, evolving with Brisbane itself. "We have a running joke about Cross River Rail, that the more you look at it, the bigger it gets," Vine said, noting that after the project began, the city was selected to host the 2032 Summer Olympic Games. "We have an opportunity to take what we've done here as part of building a railway line and stretch it to include everything we're going to need to build for the Olympics."

Vine even foresees the twin being a tool for operating the system in addition to its value in design, construction, and project management. "We realized we've built a digital twin that will help run the railway," he said. "So there's almost a whole second chapter waiting to be written."

Terry Bills

Terry Bills is the Global Transportation Industry Director at Esri, responsible for all transportation infrastructure segments worldwide. He has more than 25 years of experience in transportation, working on planning, policy development, information technology and GIS. He has been a principal planner for a large regional transportation planning agency, as well as the president of a GIS and transportation consulting firm. He was a doctoral candidate at UCLA, where he also earned two Masters' degrees.

Ian Koeppel

At Esri Ian leads international business development for transportation markets in Europe. He is a Cultural Geographer, residing in the Loire-Atlantique region of France. Before joining Esri in 1998, Ian was Regional Sales Manager at Etak (now TomTom), Managing Consultant at Accenture, and Director of Management Information Systems at the City of New York Department of Parks & Recreation. An earlier role as research manager at Neighborhood Open Space Coalition included co-authoring the book Struggle for Space: The Greening of New York City, 1970-1984.

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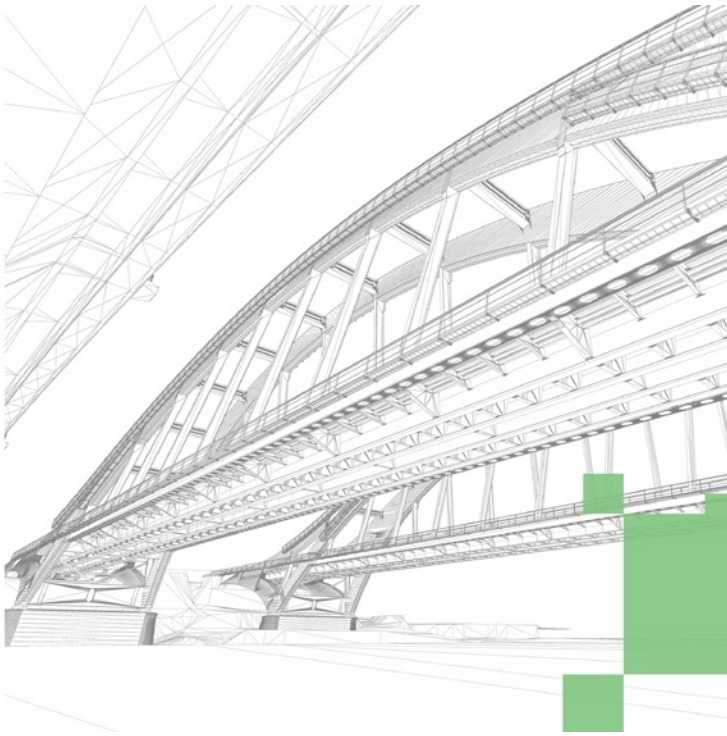

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