GEOSPATIAL WORLD

ADVANCING KNOWLEDGE FOR SUSTAINABILITY

GIS and BIM Integration for Sustainable AEC Industry Practices

AUTODESK

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INTEGRATION OF GIS AND BIM

Integrated geographic information system (GIS) and building information modeling (BIM) solutions facilitate a data-driven approach to project life cycle management, which is crucial for sustainable project outcomes.

Key Benefits

Faster plan approval and permits

Improved coordination and collaboration

Reduced cycle time of multiparty workflows

Reduced material usage

Reduced total construction cost

Increased project resiliency

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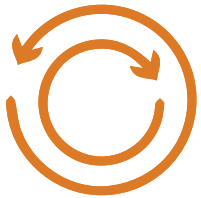
Why AEC Industry Practices Should Be Digitalized

80%

Projects overshoot their primary budget.



52%

Rework occurs during the course of the project because of poor data and communication .

35%

Weekly worker-hours are spent managing rework and handling conflicts.

20%

Projects are not completed on time.

Digital technologies combat the above-listed challenges with data for decision-making, resource management, waste reduction, and scheduling and project management. The majority of construction organizations, including small and medium-size enterprise (SME) organizations, have yet to adopt enterprise-level applications of digital technologies.

Source: Construction Disconnected report (FMI), "Imagining Construction's Digital Future" (McKinsey & Company)

Elements of Data Interoperability in the AEC Industry

Data interoperability in the AEC industry presently includes the following elements, which enable stakeholders to adopt digitalization measures across project workflows.

Open Data Standards

Cloud-based application programming interfaces (APIs) allow users to build applications that augment and integrate design and engineering data, connect existing software systems, and digitalize workflows with reliable project data. Data interoperability in the AEC industry presently includes the following elements, which enable stakeholders to adopt digitalization measures across project workflows.

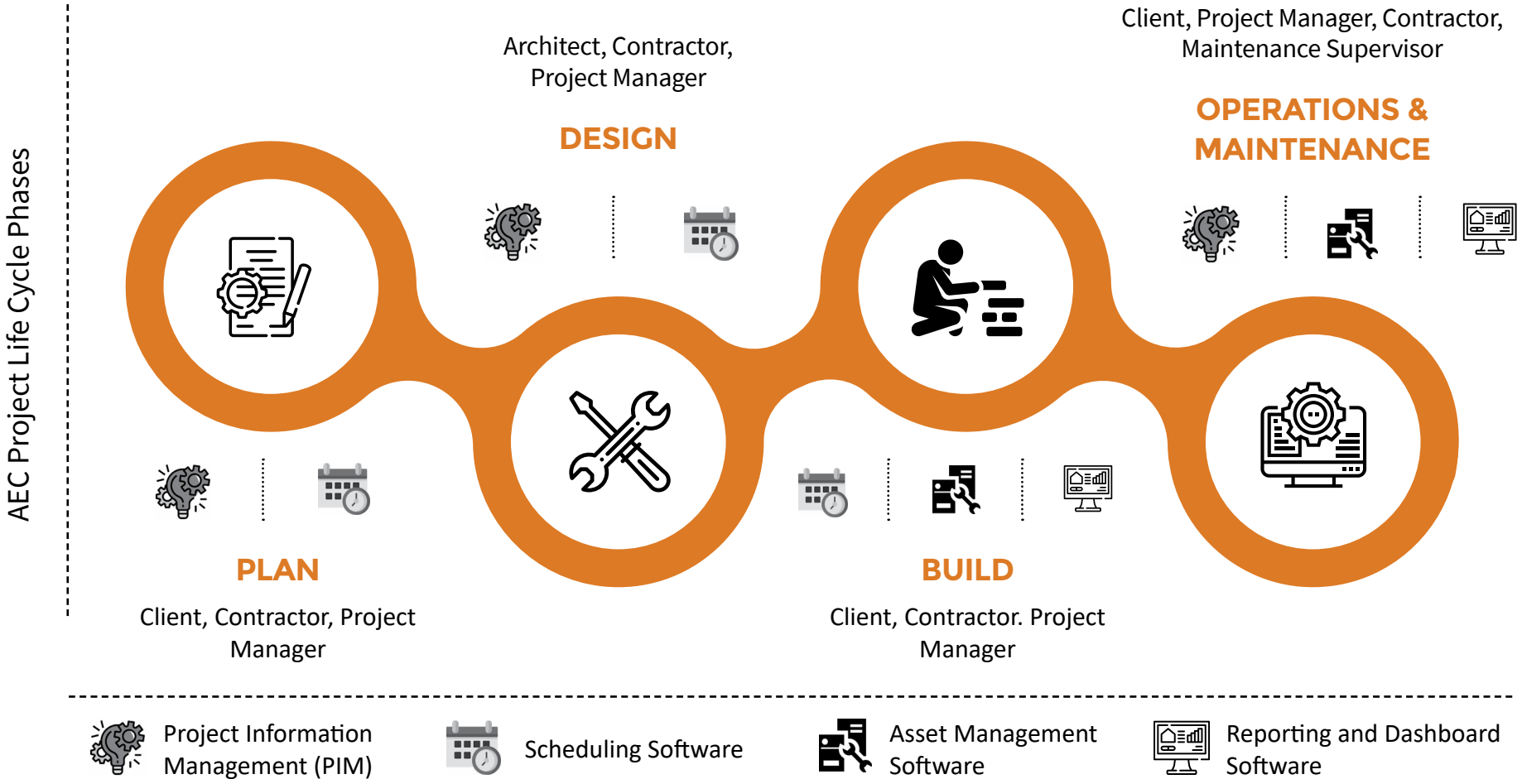
Common Data Environment

Cloud-based application programming interfaces (APIs) allow users to build applications that augment and integrate design and engineering data, connect existing software systems, and digitalize workflows with reliable project data. Data interoperability in the AEC industry presently includes the following elements, which enable stakeholders to adopt digitalization measures across project workflows.

APIs and Cloud Computing

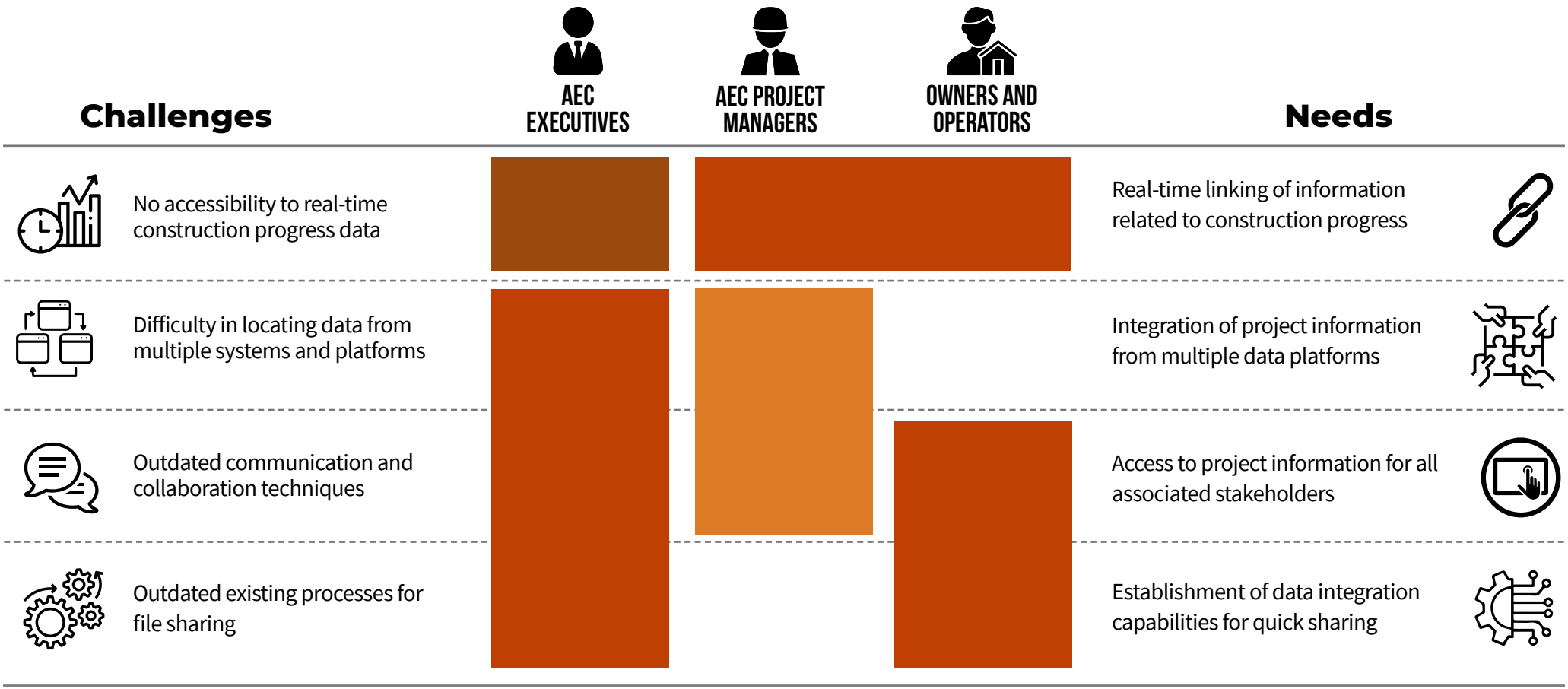
Cloud-based application programming interfaces (APIs) allow users to build applications that augment and integrate design and engineering data, connect existing software systems, and digitalize workflows with reliable project data. Data interoperability in the AEC industry presently includes the following elements, which enable stakeholders to adopt digitalization measures across project workflows.

Common Systems and Platforms–Stakeholders and Benefits

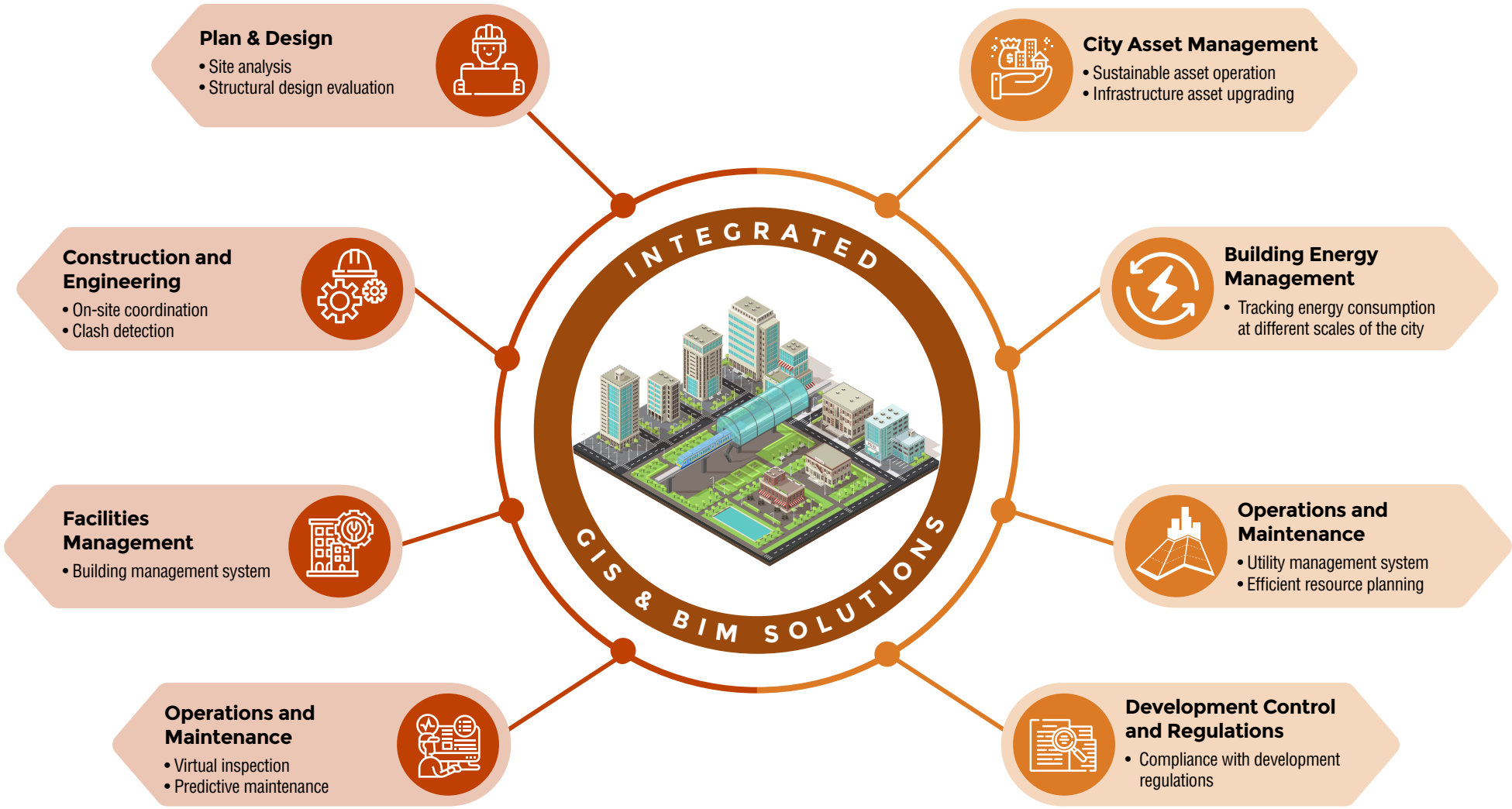


The above common data platforms include benefits like efficient collaboration, cost and performance analysis, and maintenance scheduling. However, these platforms result in project stakeholders working in silos.

Challenges, Needs and Solutions



Integrated GIS and BIM Solutions

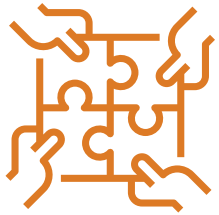


Stakeholders' Observations of Integrating GIS and BIM

Improved data accuracy reduces project risks.

59%

Organizations believed that adoption of integrated GIS and BIM for complex project design reduces risks associated with project execution, including project delays and design to execution conflicts.



Project information is integrated from multiple data platforms.

62%

Organizations decided to implement GIS and BIM for improved collaboration across multidisciplinary teams.

All stakeholders get access to project information.

55%

Project stakeholders believed that integrating GIS and BIM solutions increased collaborative workflow.

Data integration capabilities are established for quick sharing.

63%

Organizations adopted integrated GIS and BIM solutions for decreasing time taken for data retrieval and validation.

Source: Geospatial World—GIS and BIM Integration (GEOBIM) for Sustainable AECO Industry Practices, Survey 2021

Case Study Gallery

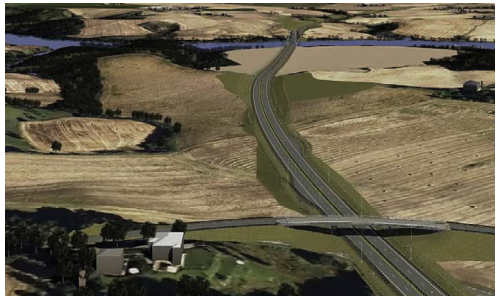
HS2 Railway Project (phase I)

Project Overview	
Location	London – Birmingham, UK
Client	Department for Transport, UK
Length	176 km
Contractors	Skanska Costain STRABAG
Total Cost	US$122 billion (GBP 88 billion)
Completion	Between 2029 and 2033

LAX Airport Development Program

Project Overview	
Location	Los Angeles, California, USA
Client	Los Angeles World Airports
Length	35 square km
Total Cost	US$15 billion
Completion Year	2028 (expected)
Stakeholders	Titan AEC, Austin Commercial, AECOM

E16 Highway in Norway



Project Overview	
Location	Oslo, Norway
Client	The Norwegian Public Roads Administration
Length	32 km
Completion Year	2025 (expected)
Stakeholders	COWI

Norwegian Railway High-Speed Rail Extension Project

Project Overview	
Location	Oslo, Norway
Client	Norwegian National Rail Administration
Length	22.5 km
Contractors	Ramboll, SWECO and COWI
Total Cost	US$1.9 billion (NOK 11 billion)
Completion Year	2024 (expected)

Case Study Gallery

Milwaukee Metropolitan Sewerage District Facilities Plan

Project Overview	
Location	Milwaukee, Wisconsin, USA
Client	MMSD
Area	1070 square km
Stakeholders	HNTB

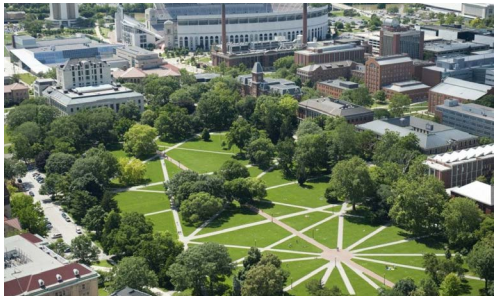
Sungai Buloh-Serdang-Putrajaya Line

Project Overview	
Location	Kuala Lumpur, Malaysia
Client	MRT Corp, Malaysia
Length	52.2 km (13.5 km underground)
Total Cost	US$7.19 billion (RM 32 billion)
Completion Year	2022 (expected)
Stakeholders	MMC Corporation Berhad, Gamuda Berhad, AECOM, and SSA Architects

SFO International Airport Capital Improvement Plan

Project Overview	
Location	San Francisco, California, USA
Client	City and County of San Francisco
Length	20.23 square km
Total Cost	US$2.4 billion
Completion Year	2023 (expected)
Stakeholders	Austin Commercial and Webcor Builders Joint Venture, HKS/ Woods Bagot/ED2 International/KYA, WSP/AGS

GIS and BIM Integration for Ohio State University Campus



Project Overview	
Location	Ohio, USA
Client	Ohio State University
Area	65 square km

Design Coordination Tracking for Collaboration–HS2 Railway Project (phase I)

London–Birmingham, UK

Project Details

The Skanska Costain STRABAG joint venture (SCS JV) is using 3D GIS, BIM, and drone technologies to design, construct, and deliver the High Speed 2 (HS2) railway project for the UK.

Project Recognition – Awards/ Certification

HS2 received the BREEAM Infrastructure Scheme Certificate for project sustainability on phase 1 of the project in 2018. HS2 is the first British infrastructure project to be awarded this certification.

Challenges

- Lack of collaboration among multi-disciplinary teams
- Preservation of environment
- Large underground construction

Solution

Autonomous drones, equipped with high-resolution cameras used in the survey, helped create accurate 3D digital topographical maps for project planning and design.

Esri's ArcGIS Enterprise allowed integration of 3D GIS data (Esri 3D City Information Model) with high-quality 3D BIM data to accurately visualize the HS2 route.

Integrated GIS and BIM solutions enabled stakeholders to visualize and collaborate on a common platform. This facilitated the automation of manual data-entry processes in the design of rail, tunnels, bridges, and earthworks with interoperable geospatial and built data.

Results

- Enhanced collaboration helped save **30 percent of project duration** in the planning stage.
- Accelerated design review process saved **20 percent of time spent** in the design stage.
- Approximately **£3 million in costs were saved** in the preconstruction stage.

Infrastructure Delivery with Project Controls Progress - LAX Airport Development Program

Los Angeles, California, USA

Project Details

As part of the LAX Development Program, Los Angeles World Airports (LAWA) is strategically leveraging GIS to streamline the workflows of multiple construction projects. It is also using BIM applications to ensure that operations of the airport proceed with minimal disruptions.

Project Recognition – Awards/ Certification

Los Angeles International Airport (LAX) received international certification for greenhouse gas reduction in 2019. LAX achieved the US Green Building Council's Leadership in Energy and Environmental Design (LEED) Gold Certification in 2015 for the Tom Bradley International Terminal.

Challenges

Lack of coordination in logistics for 130 projects in parallel

Uninterrupted airport operations despite multiple improvement projects

Solution

ArcGIS is used to create a platform called Coordination and Logistics Management (CALM), which combines Airport Enterprise GIS (AEGIS) and the document management system to help managers oversee the airport's multiple construction projects. Staff and stakeholders use the system to access all construction records and drawings. The GIS displays project locations and provides a geospatial interface for data.

Level of Development (LOD) 200-400 lidar data was integrated in a 3D model of the airport using Autodesk Revit and Autodesk ReCap. This helped in the visualization of project information and integrated GIS data to identify workflow conflicts.

Result

Lower project contingencies, risks, and costs

5D (time and cost) Design and Construction Planning– E16 Highway in Norway

Oslo, Norway

Project Details

COWI, a global engineering consulting group, integrated GIS and BIM in executing, planning, and designing a major new portion of the E16 highway—a four-lane, 32-kilometer stretch of highway in Norway.

Project Recognition – Awards/ Certification

The project won the Autodesk Excellence in Infrastructure Visualization award in 2014.

Challenges

- Project site consists of unstable clay soil (prevalent in the region)
- Workers distributed across two countries and three municipalities
- Diverse landscape prone to geotechnical and flooding challenges

Solution

COWI began development of a 3D model of terrain conditions along the proposed route. This included collection of data—about land, geology, flooding, natural resources, agriculture, and forestry from free government GIS databases—to put into the 3D model.

The conceptual design was created in Autodesk InfraWorks 360 and it helped create various planning scenarios in a 3D environment. These were communicated to subcontractors and consultants.

The use of GIS, along with Autodesk InfraWorks, helped COWI expedite the finalization of the highway route.

Results

- Data-led decision-making accelerated the design process.
- The project achieved **10 percent greater cost efficiency** in preliminary design stage.

Design Coordination Tracking for Collaboration–Norwegian Railway High-Speed Rail Extension Project

Oslo, Norway

Project Details

The Ramboll-SWECO team integrated GIS and BIM solutions to fast-track the Norwegian railway high-speed rail extension project.

Challenges

- Uneven and undulating ground conditions and challenging nature of the soil on-site
- Preservation of environment
- Construction over vast stretches of urban area

Solution

ArcGIS helped overlay project information related to critical constraints and proposed design models. This enabled the team to effectively communicate design intent and issues to over 120 stakeholders and accelerate design approvals.

InfraWorks served as the CDE for the entire project team, which facilitated a rigorous schedule of project reviews every 14 days. InfraWorks accelerated the process of modeling because of its ability to bridge the gap between 2D drawings and 3D modeling. This process is called Integrated Concurrent Engineering (ICE).

Results

Implementing connected BIM processes in the planning and approval phase of the project helped save **20 percent of project duration time.**

Comprehensive City Planning for Large or Multiple Sites– Milwaukee Metropolitan Sewerage District Facilities Plan

Milwaukee, Wisconsin, USA

Project Details

Infrastructure firm HNTB integrated applications—lidar, BIM, and GIS—to improve access and retrieval of as-built conditions and data for Milwaukee Metropolitan Sewerage District (MMSD) employees and associated stakeholders.

Challenges

- Project data in silos
- Much time taken to perform manual scanning of facilities

Solution

Esri's ArcGIS engine was selected as the primary platform to overcome the project challenges and increase operational efficiency. The project was implemented in multiple phases and included the development of a business data model that focused on existing data inventory - including improved mapping and organizational efficiencies, as well as bringing added value to MMSD business operations.

More than 100 scans were collected every day via LiDAR survey tools and integrated into BIM applications and into the ArcGIS environment. This helped the staff access related data in external databases, including documents relevant to the 3D model feature the user selected.

Results

- Enhanced facilities management and operational efficiencies
- Reduced energy consumption
- Easy access to as-built data for all relevant stakeholders

Infrastructure Delivery with Project Controls Progress–Sungai Buloh-Serdang-Putrajaya Line

Kuala Lumpur, Malaysia

Project Details

The MMC Corporation Berhad and Gamuda Berhad joint venture is utilizing Level 2 BIM along with ArcGIS solutions to enhance productivity, efficiency, and quality for the delivery of the Sungai Buloh-Serdang-Putrajaya rail line project.

Project Recognition – Awards/ Certification

The project won two Asia Geospatial Excellence Awards in 2017 for its extensive and innovative use of geospatial technology in two categories: Transport Infrastructure and Digital Engineering.

Challenges

- Numerous on-site changes during construction
- Delays in design submission due to poor project information management
- Lack of coordination among different teams in identifying project conflicts

Solution

The 2.3 terabytes of information are stored in the cloud-based CDE—comprising 70,000 pages of 3D models, 200,000 drawings, and 30,000 documents—shared by more than 700 users from various stakeholders. This helped identify potential challenges and design conflicts through visualization and advanced modeling.

The Esri ArcGIS technology-powered SSP Line Geospatial Web Portal helped enhance collaboration across the board, between 150 team members from various units or disciplines. The teams include Geotech, Program Planning, Safety Quality, and Civil & Tunnel. The contractors associated with these teams utilized the Geospatial Web Portal in viewing, analyzing, and querying data at any location and at any time.

Results

- The Geospatial Web Portal **increased design and coordination productivity by 35 percent.**
- The Geospatial Web Portal **increased design and coordination productivity by 35 percent.**

Infrastructure Delivery with Project Controls Progress–SFO International Airport Capital Improvement Plan

San Francisco, California, USA

Project Details:

San Francisco (SFO) International Airport's multibillion-dollar capital improvement plan combines GIS, CAD, and BIM solutions to transform infrastructure data management and operations.

Project Recognition – Awards/ Certification:

SFO International Airport's Terminal 2 is the first airport terminal in the United States to be certified LEED Gold. The new terminal, scheduled to open in 2023, is expected to meet the project requirements for a similar LEED Gold Certification.

Challenges

Lack of coordination in logistics for more than 200 projects in parallel

Maintenance of huge repository of data on a single platform

Solution

ArcGIS supports capture of spatial information related to infrastructure in real time and provides easy access. This helps in designing optimal routes to complete tasks and enhance logistics and fleet management significantly.

ArcGIS also helped stakeholders in identifying clashes beneath the surface and avoiding rework. Autodesk BIM 360 Design's cloud collaboration feature is being used to maintain complex design coordination among project teams. This takes place in the form of collaboration between studios, contractors, and engineers with BIM 360 for streamlining the process, from design to delivery.

Result

GIS and BIM were used together to create the project model that will enhance the resilience and sustainability of the facilities for 40–50 years.

Construction Progress with Field Issue Entry and Management–GIS and BIM Integration for Ohio State University Campus

Ohio, USA

Project Details

The Ohio State University (OSU) integrated GIS and BIM solutions to develop a digital twin to provide life cycle support and management to hundreds of facilities on OSU's campus.

Challenges

- Limited infrastructure facilities
- Lack of collaboration between stakeholders due to reduced accessibility to data

Solution

ArcGIS is used as an asset management system for data collection, management, analysis, planning, design, and construction. This enables dynamic filtering and symbolization of campus buildings with respect to various filters like building use, condition, and amenities.

Autodesk Revit was used to compile, connect, and digitally construct an accurate 3D model of a building by assembling the multiple 2D drawings used in its construction and documentation.

The ArcGIS software-supported the asset management system which allows these 3D models to be as up-to-date as possible and ensures that they reflect each building's current state.

Results

- Enhanced support for facilities management, maintenance, and safety
- Access to data for relevant decision-makers
- Smart energy consumption monitoring

SUMMARY

Integrated GIS and BIM solutions for sustainable project delivery methods have an inherent advantage over conventional project delivery mechanisms.

Assessment of project workflows, seamless data exchange, and the ability to share with interoperable capabilities are imperative for project goals such as reducing delays, costs, and reworks.

Application of integrated GIS and BIM solutions in early design and construction helps achieve these sustainability goals.

List of Citations

HS2 Railway Project (phase I)

"Digital Technologies Save UK's HS2 Project at Least £3 Million in Costs," GW Prime, 2020. <https://www.gwprime.geospatialworld.

net/case-study/digital-technologies-save-uks-hs2-project-at-least-3-million-in-costs/>

Wikipedia's "High Speed 2" entry, 2021. <https://en.wikipedia.org/wiki/High_Speed_2>

"High Speed 2 (HS2) Railway, UK," Railway Technology, 2020.

<https://www.railway-technology.com/projects/high-speed-2-hs2/>

LAX Airport Development Program

Real-World Solutions Using Geospatial Models: Transportation, Esri, 2020. <esri.com/content/dam/esrisites/en-us/media/ebooks/aec-transportation-ebook-dl-fnl.pdf>

"LAX of the Future: Customize SharePoint GIS to Provide Construction Information," Chinery, D., R. Mock, Los Angeles World Airports, Esri User Conference, 2019.

<esri.com/content/dam/esrisites/en-us/about/events/media/UC-2019/user-presentations/UC_62.pdf>

Los Angeles International Airport (LAX), AECOM, 2021.

<https://aecom.com/projects/los-angeles-international-airport/>

"LiDAR at LAX," Baadkar, S., D. Rodriguez, Autodesk, 2019.

<https://www.autodesk.com/autodesk-university/class/LiDARLAX-2019>

E16 Highway in Norway

"Intelligent Models for Roadways—A New Way to Work," M. Sekse, Autodesk, 2015. <https://damassets.autodesk.net/content/

dam/autodesk/www/solutions/bim/images/stories/Intelligent-Models-for-Roadways.pdf>

"Civil Infrastructure Design: The Future Relies on Intelligent Designs Based on Real-World Context," B. Del Rosario, Geospatial World, 2016. <https://www.geospatialworld.net/article/civil-infrastructurefuture-

relies-bim/>

"Taking the Faster Road with 3D," Geospatial World, 2016.

<https://www.geospatialworld.net/article/taking-the-faster-roadwith-3d/>

Trends and Practices Using 3D Visualizations for Large-Scale Landscape Projects in Norway, Hassan, R., F. Saetre, K. Andreas Oyvang, CUMINCAD, 2016. <http://papers.cumincad.org/data/works/att/ascaad2016_029.pdf>

COWI—E16 Highway—Visualization Award (Video 2 of 2), Autodesk Video Magazine, 2014. <https://www.autodeskmagazine.com/cowi-e16-highway-visualization-award-video-2-of-2>

Norwegian Railway High Speed Rail Extension Project

BIM & GIS Integration, Autodesk, 2018. <https://damassets.

autodesk.net/content/dam/autodesk/www/solutions/bim/docs/autodesk_bring_together_bim_gis_ebook_v18.pdf>

"Follo High-Speed Railway Line, Oslo," Railway Technology, 2016. <https://www.railway-technology.com/projects/folloline/>

Wikipedia's "High-Speed Rail in Norway" entry, 2021. <https://en.wikipedia.org/wiki/High-speed_rail_in_Norway>

"Norway's Largest Transport Project Prepares Oslo for Future Growth," Ramboll, 2015. <https://ramboll.com/projects/rno/folloline-2015>

"Large Rail Project Alleviates Norway's Urban Pressure," Ramboll, 2016. <https://ramboll.com/projects/rno/sandbukta-mosssastad>

Milwaukee Metropolitan Sewerage District Facilities Plan

"A Technology TrifectaLiDAR, BIM, and GIS Converge to Bring Business Efficiencies to Milwaukee Metropolitan Sewerage District," LIDAR magazine, 2012. <https://lidarmag.com/2012/11/16/atechnology-

trifectalidar-bim-and-gis-converge-to-bring-businessefficiencies-to-milwaukee-metropolitan-sewerage-district/>

2050 Facilities Plan, MMSD, 2020. <https://www.mmsd.com/government-business/2050-facilities-plan>

Sungai Buloh-Serdang-Putrajaya Line

"GIS Helps Keep Malaysia's MRT2 Project on Track," Esri Malaysia, 2019. <https://esrimalaysia.com.my/news/gis-helps-keepmalaysias-mrt2-project-track>

"KVMRT Bags Geospatial Awards," AECOM, 2017. <https://aecom.com/my/kvmrt-bags-geospatial-awards/>

"Overall Construction of MRT 2 SSP Line 70% Completed," The Star, 2020. <https://www.thestar.com.my/business/businessnews/2020/03/11/overall-construction-of-mrt-2-ssp-line-70-completed>

Putrajaya Line, MRT Corp, 2017. <https://www.mymrt.com.my/public/putrajaya-line/>

MRT Line 2 (SSP) Underground Works, Construction Plus Asia. <https://www.constructionplusasia.com/my/mrt-line-2-sspunderground-work-2/>

Sungai Buloh-Serdang-Putrajaya Line (SSP Line), Railway Technology, 2021. <https://www.railway-technology.com/projects/sungai-buloh-serdang-putrajaya-line-ssp-line/>

"MMC-Gamuda Formalises Role in MRT2 as Turnkey Contractor," The Edge Markets, 2020. <https://www.theedgemarkets.com/article/mmcgamuda-formalises-role-mrt2-turnkey-contractor>

SFO International Airport Capital Improvement Plan

"A Flying Start for Data Integration, Informed Infrastructure," Esri, 2021. <esri.com/content/dam/esrisites/enus/

media/case-studies/san-francisco-international-airport-user-story.pdf>

Designing Beyond—Improving Airport Operations through BIM, M. Day, Airport Cooperative Research Program, 2020. <http://onlinepubs.trb.org/onlinepubs/webinars/200922.pdf>

"San Francisco International Rebuilds Terminal for $2.4 Billion," J. Richards, Airport Improvement, 2020. <https://

airportimprovement.com/article/san-francisco-int-l-rebuildsterminal-1-24-billion>

"Watch: How Technology Is Driving the Largest Redesign in SFO History," E. Dsouza, Convergence, 2018. <https://projectdelivery.autodesk.com/blog/airport-design/>

GIS and BIM Integration for Ohio State University Campus

"GIS and BIM Provide Life Cycle Support for University's Assets," J. Baumann, Esri, 2018. <esri.com/about/

newsroom/arcuser/gis-and-bim-provide-life-cycle-support-foruniversitys-assets/>

"CAD, BIM, & GIS Integration—Linking Design with Context to Drive Life Cycle Value," Renteria, A., L. Kruger, Esri, 2020. <esri.com/content/dam/esrisites/en-us/events/conferences/2020/federal-gis/cad-bim-gis-integration.pdf>

List of Abbreviations

2D—two-dimensional

3D—three dimensional

4D—four dimensional

4IR—Fourth Industrial Revolution

5D—five dimensional

AEC—architecture, engineering, and construction

AEGIS—Airport Enterprise GIS

API—application programming interface

BIM—building information modeling

BREEAM—Building Research Establishment Environmental Assessment Method

CALM—Coordination and Logistics Management

CDE—Common Data Environment

GBP—Great Britain pound

GIS—geographic information system

HS2—High Speed 2

ICE—Integrated Concurrent Engineering

KVMRT—Klang Valley Mass Rapid Transit

LAWA—Los Angeles World Airports

LAX—Los Angeles International Airport

LEED—Leadership in Energy and Environmental Design

lidar—light detection and ranging

LOD—Level of Detail

MMSD—Milwaukee Metropolitan Sewerage District

MRT—Mass Rapid Transport

NOK—Norwegian krone

OSU—Ohio State University

PIM—Project Information Management

RM—Malaysian ringgit

SCS JV—Skanska Costain STRABAG joint venture

SFO—San Francisco

SME—small and medium-size enterprise

SSP—Sungai Buloh-Serdang-Putrajaya

UK—United Kingdom

USA—United States of America

US$—United States dollar

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