BIM ADVANCEMENTS MADE THE DIFFERENCE

Bentley®
Sustaining Infrastructure

>

THE WORLD OF ARCHITECTURE, ENGINEERING, AND CONSTRUCTION IS CHANGING

The world of architecture, engineering, and construction is changing. New ways of working and new tools are transforming the face of the industry, allowing architects, designers, engineers, and contractors to work more quickly, accurately, and cost effectively. New processes and technologies are making it easier to collaborate and coordinate projects, and keep track of changes.

BIM (Building Information Modeling) processes are advancing infrastructure.

BIM Advancements made the difference:

- Between a city grinding to a halt during a major construction project and the economy carrying on as normal
- Between learning from your mistakes and getting it right first time
- Between hit-and-miss data sharing and seamless collaboration
- Between escalating costs and a multitude of savings

There are three pillars to every BIM project:

- People
- Process
- Technology

BIM is a set of processes, standards, and cultural changes, needed to deliver better project and asset outcomes.

From a technology perspective, a BIM strategy enables the integration of data-rich models and project information data bases, to build a virtual representation of a project and all assets. All stakeholders can access reliable information, making collaboration easier, reducing risks, and improving ROI.

Bentley offers a range of software solutions and services to help you implement BIM on projects of all types and sizes as shown by the case studies that follow.

KEY FACTORS FOR BIM SUCCESS

Five key factors that make a BIM project different.

Total Control >

Gain absolute control over every aspect of a project

Digital Rehearsal >

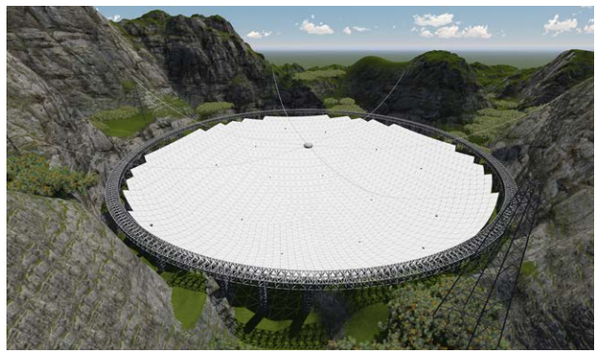
Build a project virtually before construction begins

Profitability >

Improve ROI in every area of a project

Collaboration >

Enable team members to work together more effectively, even when they are miles apart



Risk Reduction >

Eliminate risks and resolve problems before they even happen.

BIM Advancements make the difference. >

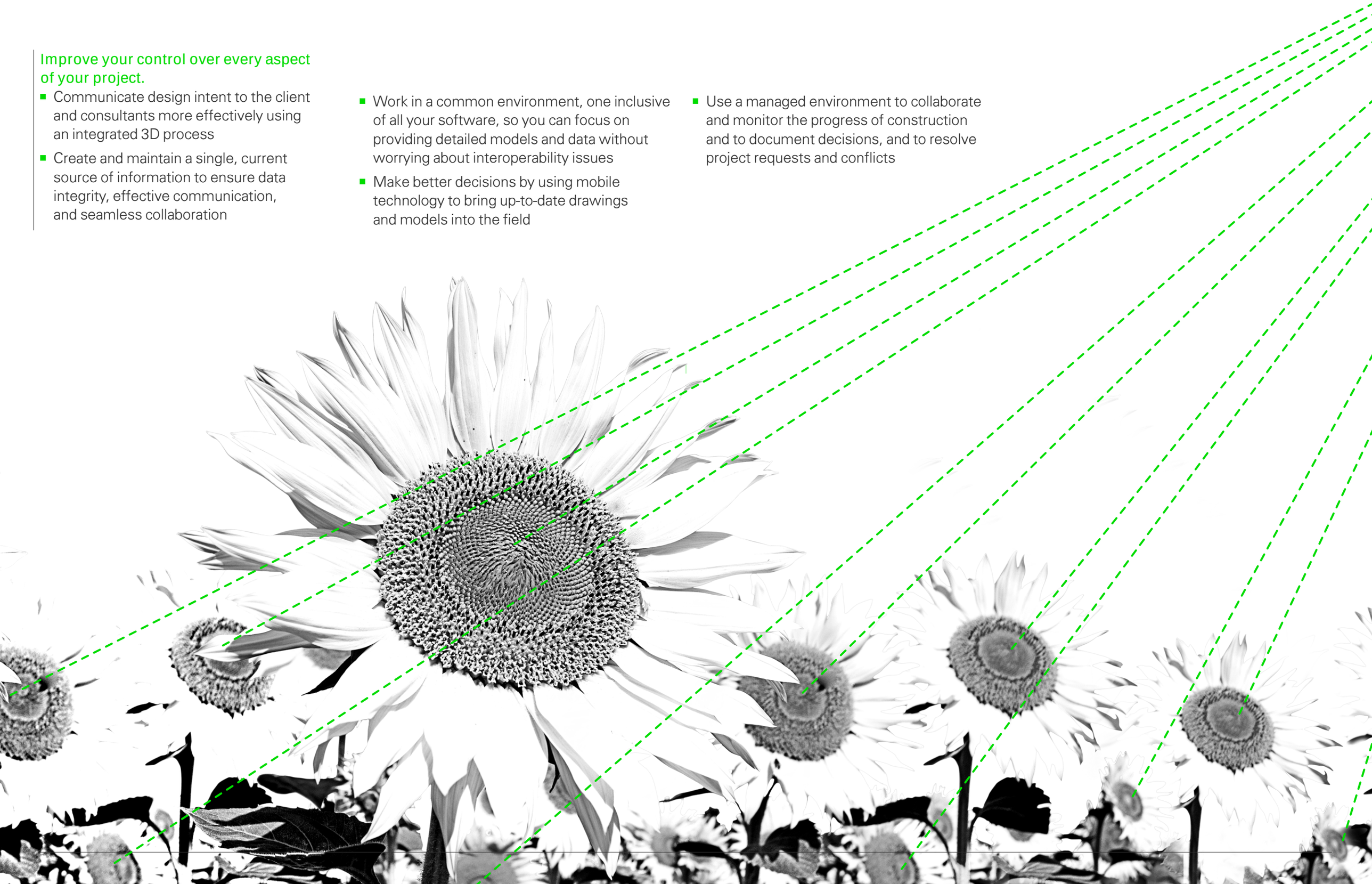
Get your organization ready to advance BIM.

Bentley Sustaining Infrastructure

TOTAL CONTROL

Improve your control over every aspect of your project.

- Communicate design intent to the client and consultants more effectively using an integrated 3D process
- Create and maintain a single, current source of information to ensure data integrity, effective communication, and seamless collaboration
- Work in a common environment, one inclusive of all your software, so you can focus on providing detailed models and data without worrying about interoperability issues
- Make better decisions by using mobile technology to bring up-to-date drawings and models into the field
- Use a managed environment to collaborate and monitor the progress of construction and to document decisions, and to resolve project requests and conflicts



EMERSON COLLEGE

Location
Los Angeles, California, United States

Project Cost
USD 85 million

Organization
Morphosis Architects

Aim
Design and build the Hollywood base of a world-renowned communication and arts college.

Challenges
- The building had to bring together student accommodation, teaching rooms, and administrative offices in one urban space, without losing the relaxed atmosphere of a college campus.
- The design had to be inspiring and reflect the identity of the college while remaining within budget.
- Sustainability was a key consideration for the design team.

Solution
Adopt integrated BIM processes to design a building that interacts dynamically with the natural environment; create a sustainable building that will foster creativity, learning, and social interaction; and deliver the complex building within budget.

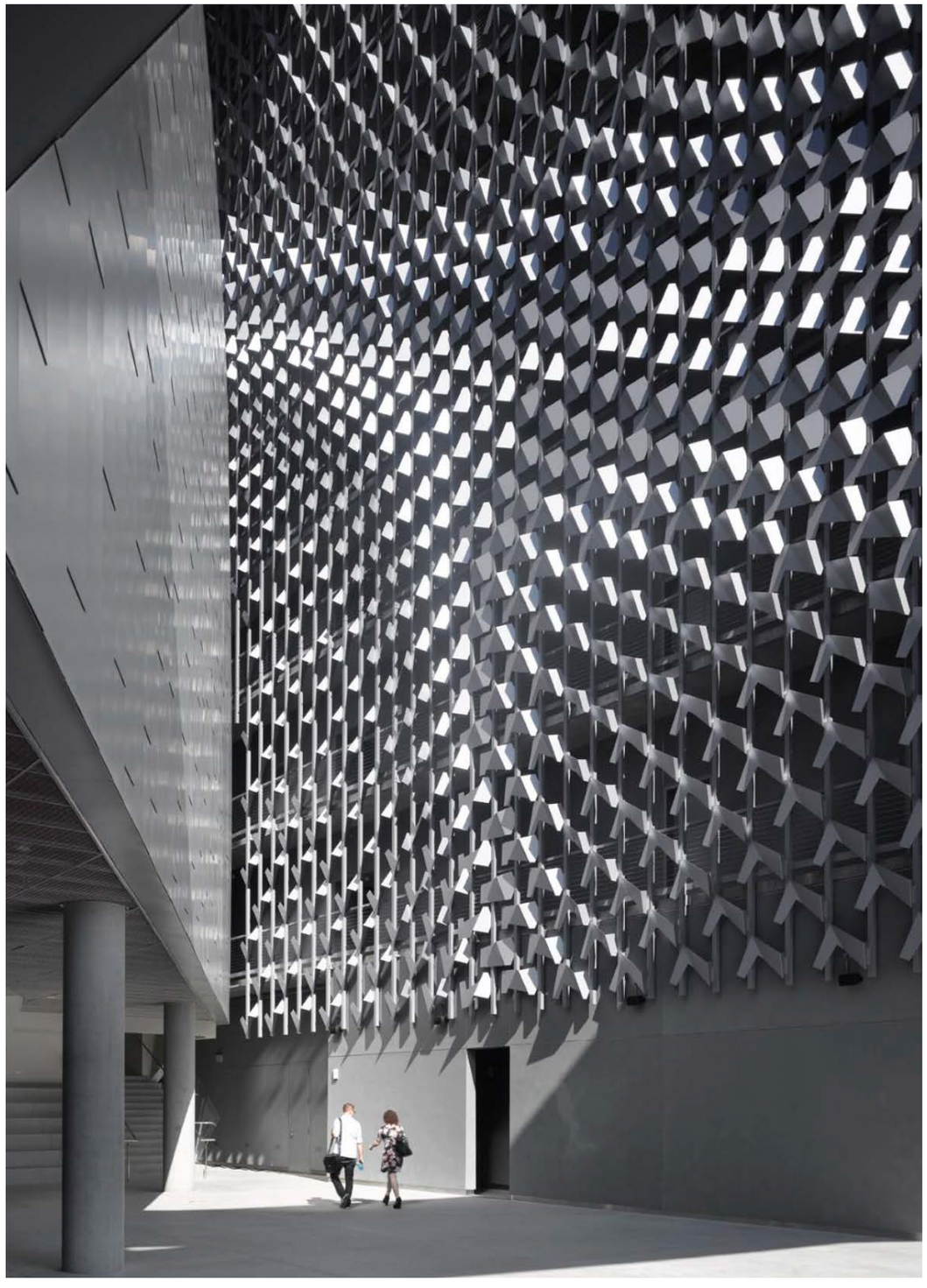
Folded Panel Solar Screen

One of many engineering challenges was the design of the folded panel solar screen, a key element of the ventilation system. The building is covered with a solar screen made of folded panels that help to lower its temperature. Visually, the screen acts as a dynamic façade that changes the way the building looks, creating shadows and reflections as the sun passes over its surface.

Morphosis used Bentley's modeling platform to model a series of folded panels of different shapes that would form the screen. The team then used the model to work out the dimensions of the flat panels but it found that its original design would waste material and take the screen over budget.

Using ProjectWise to collaborate with the manufacturer early on, the team was able to redesign the panel using a standard aluminium panel as a base. This design was much more efficient: the team limited the number of unique panels to 17, achieved the same environmental and aesthetic benefits, and reduced material waste from 28% to 9%.

Bentley solutions provided the design team with an open and stable platform for its integrated design process. The team was able to simultaneously explore complex architectural spaces and coordinate intricate building systems, and rapidly generate prototype models for 3D printing, CNC milling, and 2D drawings. Bentley's developments in cross-platform interoperability allowed for a seamless workflow between the architect, project consultants, general contractor, and subcontractors. This minimized costly misunderstandings and ensured the project remained on schedule and on budget.



"The shared access to BIM data allowed all stakeholders to effectively and efficiently work in an open platform to deliver this innovative academic building on budget and on schedule."

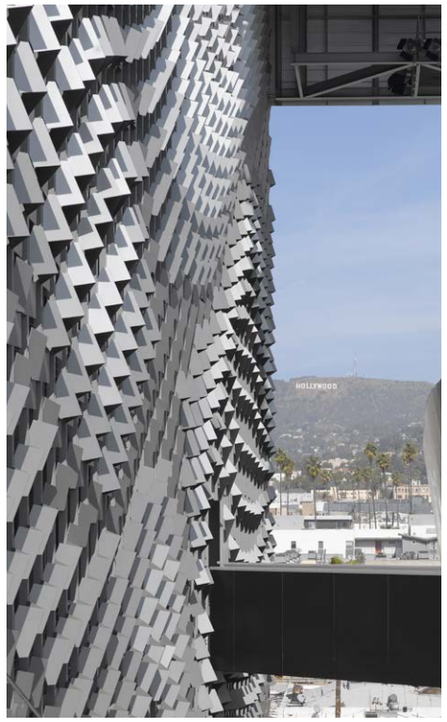
Cory Brugger, Director of Design Technology, Morphosis

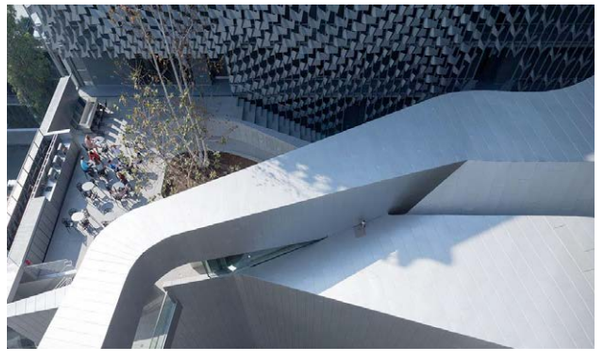
Lessons Learned

- Improve efficiency, eliminate waste, and maximize value across the project lifecycle by integrating people, systems, and practices into a process that harnesses the insights of everyone involved.
- Engage every team member early on in the process and provide the right training. BIM classes were given to all project participants. Familiarity with the Bentley platform and these processes meant the design team could run effective clash detection and co-ordination meetings with every trade involved on the project.
- Use mobile technology to bring important documents on site and allow real-time collaboration on key aspects of the construction phase.

Bentley Applications Used

- AECOsim Building Designer
- GenerativeComponents
- MicroStation
- Bentley Navigator
- ProjectWise

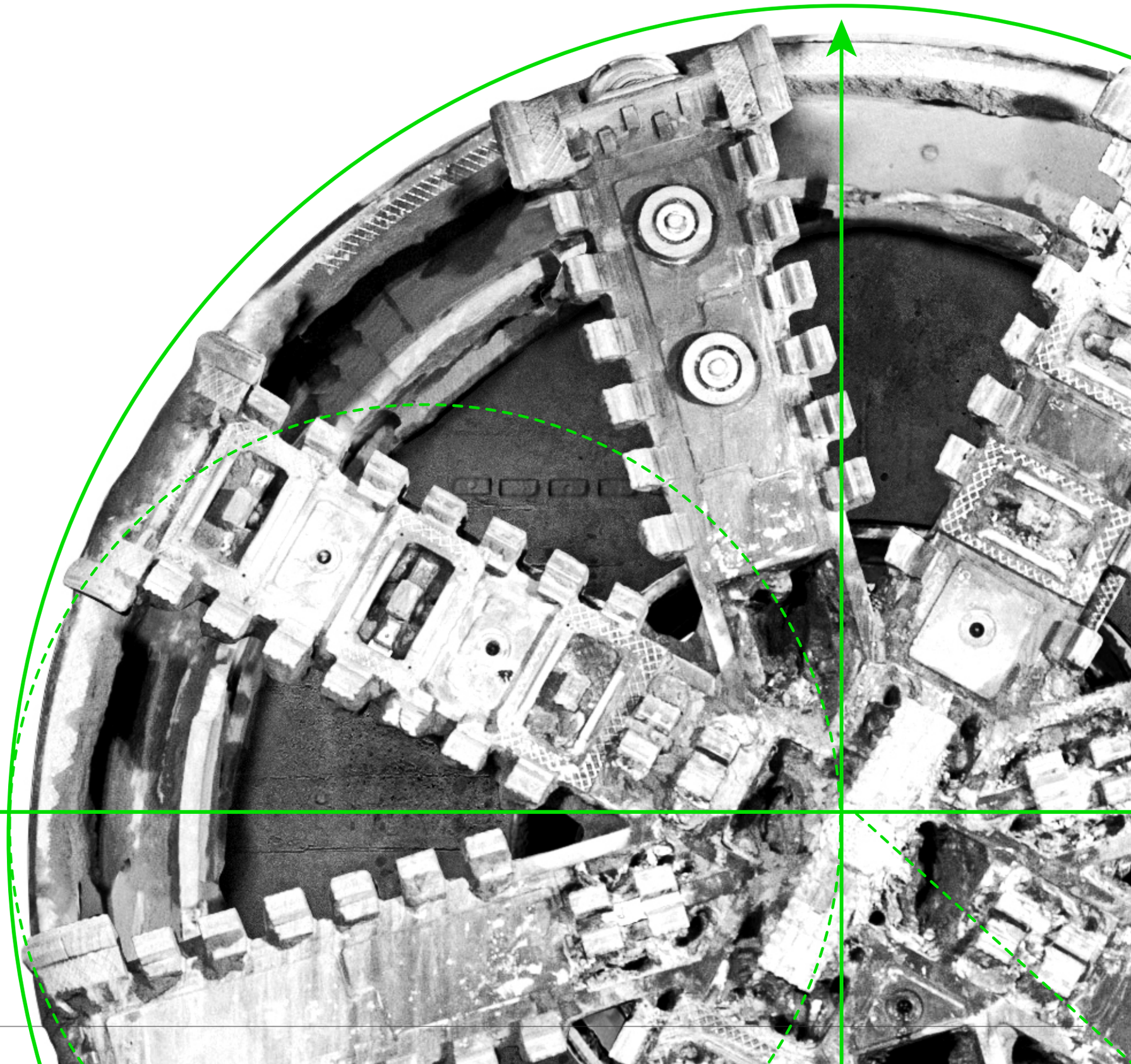


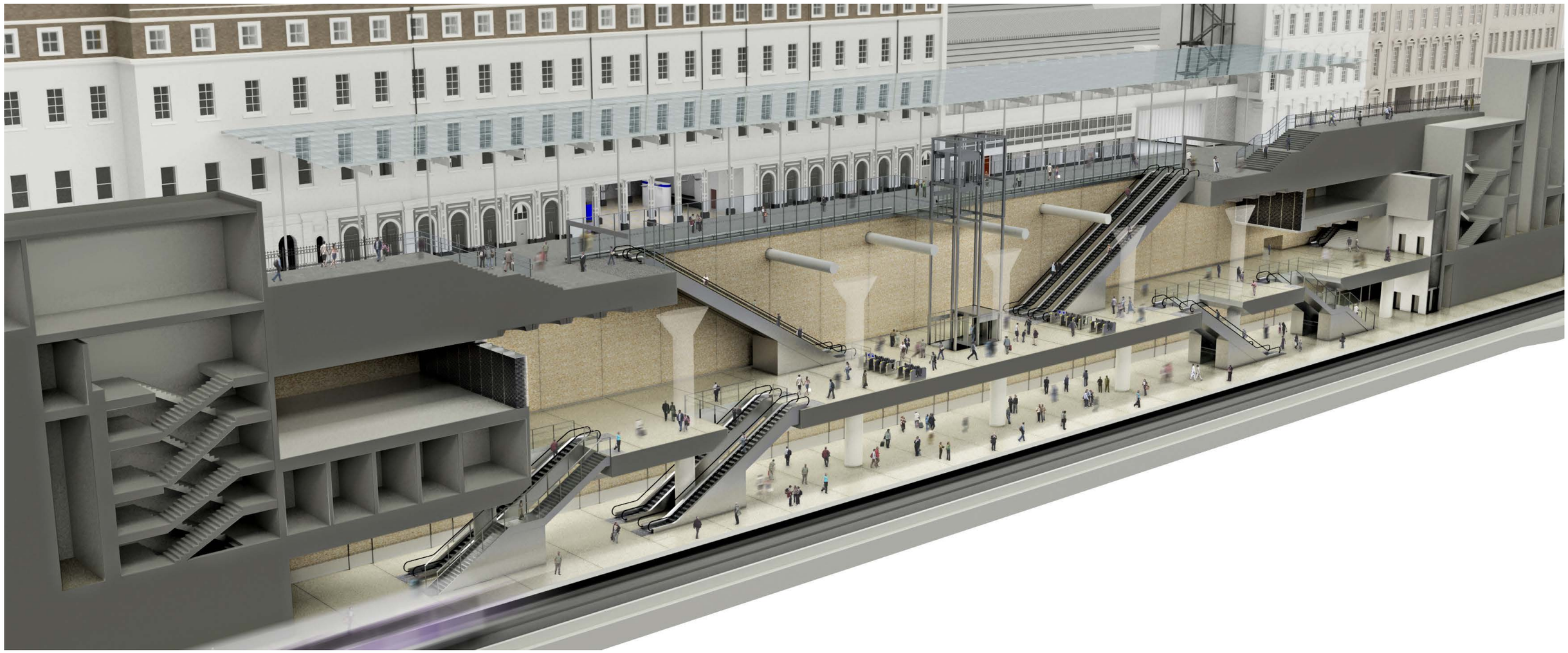


DIGITAL REHEARSAL

Build a project virtually before construction begins, so you can:

- Create and manage information throughout the project lifecycle by linking model-based technologies with project information databases
- Integrate all design models into one centralized set of linked databases for early-stage visualizations of each project element
- Improve planning and co-ordination between all disciplines by gaining greater visibility into the design and construction interfaces and activity
- Analyze and verify construction method options prior to commencing works on site
- Give all your contractors access to a simulated environment where they can find detailed technical information about the project processes and systems





CROSSRAIL

Location
London, United Kingdom

Project Cost
GBP 14.8 billion

Organization
Crossrail Ltd

Aim
Transform transport across London, reduce congestion, and bring an extra 1.5 million people within 45 minutes of the capital.

Challenges
- Creating a world class railway safely and cost effectively.
- Building over 21 kilometers of new twin-bored tunnels and nine new stations beneath London in close proximity to existing infrastructure.
- Effectively coordinating and communicating with over 100 contractors and more than 10,000 people working across the project supply chain.

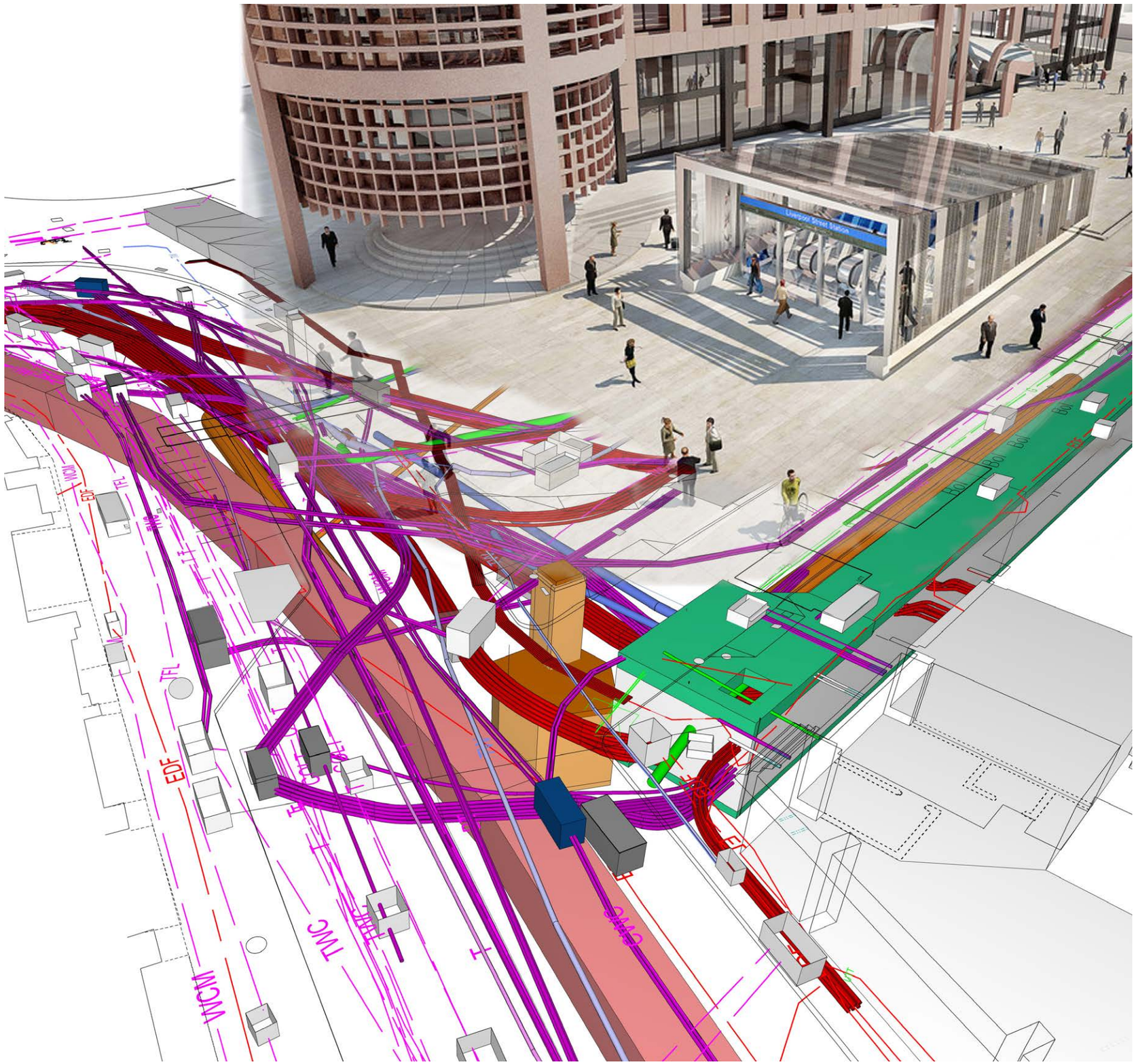
Solution
Formulate and adopt a coherent technical information strategy that use BIM processes across the project lifecycle from design and construction to operations and maintenance. Create a BIM Advancement Academy for contractors and other stakeholders to ensure everyone is trained to work to the same processes and standards.

Example: Coordinating Construction on a Tunnel

At any of the Crossrail worksites there are many disciplines, from tunneling and signaling, to station design to architecture all working within the complex and sensitive urban environment of London. Interfacing a project of this complexity demands a high level of collaboration and true coordination amongst all the project teams.

With all these teams working at the same time, within the same space, Crossrail needed to ensure that everyone used the right information, the same processes, and the same formats, and that they fully understood each other's interfaces. Crossrail had to implement stringent workflow controls and establish new processes to make the tunnel build possible. In order to keep errors and unexpected problems to a minimum, Crossrail decided that, from the outset, it had to define precise requirements for working together with each of the different partners on the contract.

Using a BIM-driven strategy, the project teams carefully planned out the correct construction sequence, and coordinated the contractors and handovers to make them as time efficient as possible. ProjectWise provided the team with a single source of truth for all design information. Crossrail used Bentley's federated approach to information modeling together with its wide portfolio of integrated design applications all available on a common data environment, offering complete data interoperability.

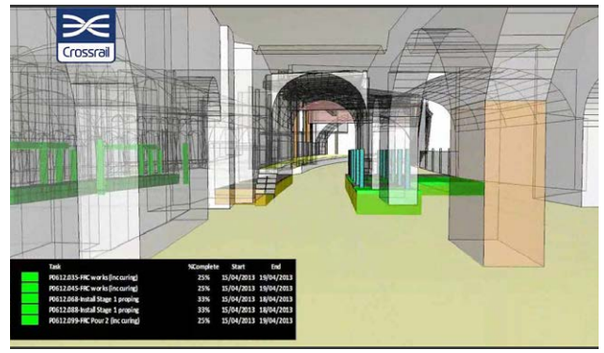


Lessons Learned

- Create a common data environment with BS and PAS 1192 standards at its core, where every stakeholder can share and access the information they need.
- Begin with the end in mind and identify how the information will be used downstream. Ensure you can capture all asset information for operations and maintenance and across the entire asset life.
- Ensure all contractors and the whole supply chain understand the BIM vision, and why the data is so valuable.
- Promote shared knowledge and upskill your supply chain.
- Mitigate project risks through the education and training of project delivery teams and the supply chain to gain their understanding of Crossrail's BIM strategy; ensure compliance with project protocols, standards, and processes and make sure everyone is working in a coordinated and integrated way.
- Test everything virtually first, "construct" assets virtually before moving to the physical world.

Bentley Applications Used

- MicroStation
- ProjectWise
- Bentley Navigator
- Engineering Content Management
- Bentley Rail Track
- InRoads
- AECOsim Building Designer
- Bentley Map
- Geo Web Publisher
- STAAD.Pro
- gINT



"Our focus is to build Crossrail digitally as well as physically, to create a railway that is efficient and effective in both construction and operation.

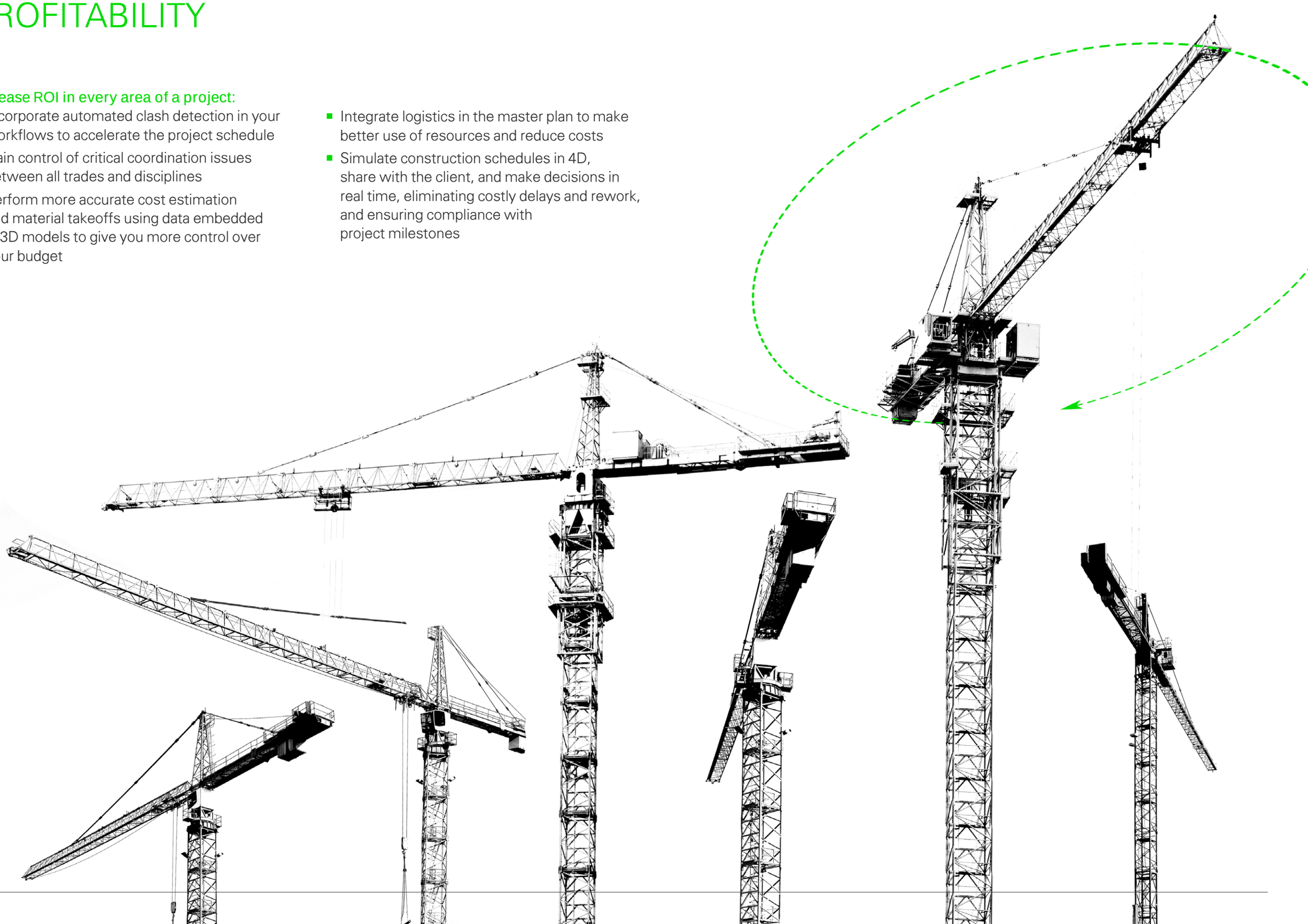
By utilising BIM concepts we connect multiple, structured sources of information into our CDE, which enables teams to aggregate multiple data sources and create smart infrastructure. It facilitates better decision-making and informed management at every stage of a project – from design through construction and into operations."

Malcolm Taylor, Head of Technical Information, Crossrail

PROFITABILITY

Increase ROI in every area of a project:

- Incorporate automated clash detection in your workflows to accelerate the project schedule
- Gain control of critical coordination issues between all trades and disciplines
- Perform more accurate cost estimation and material takeoffs using data embedded in 3D models to give you more control over your budget
- Integrate logistics in the master plan to make better use of resources and reduce costs
- Simulate construction schedules in 4D, share with the client, and make decisions in real time, eliminating costly delays and rework, and ensuring compliance with project milestones



ABU DHABI AIRPORT, MIDFIELD TERMINAL BUILDING

Location
Abu Dhabi, United Arab Emirates

Organization
Consolidated Contractors Company (on behalf of TCA-JV)

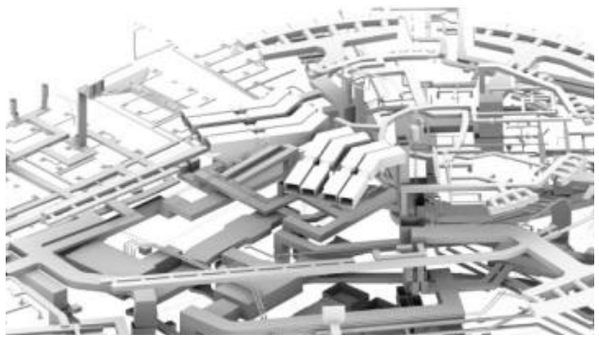
Project Cost
USD 3 billion

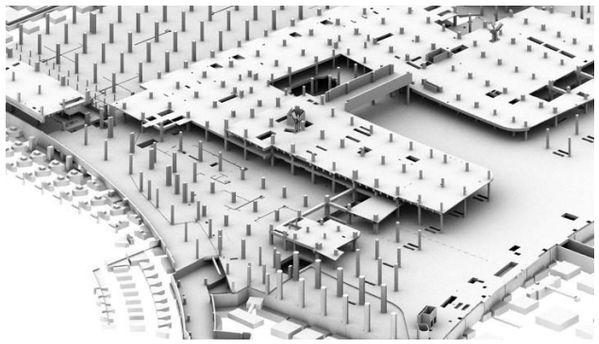
Aim
Design and build an airport terminal with a capacity of 40 million people a year without going over budget.

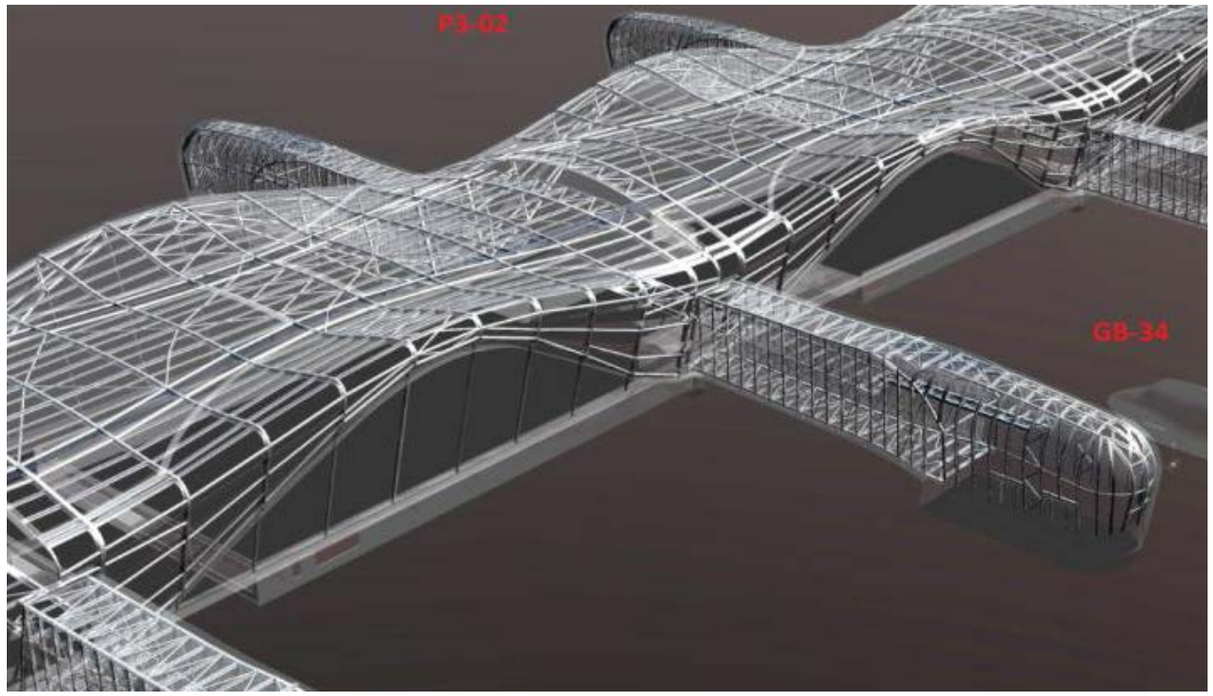
Challenges
- The complex structure and shape posed a series of difficult engineering, procurement, and construction challenges.
- The terminal building will cover 750,000 square meters and require 69,000 tonnes of steel and 500,000 square meters of cladding. For a project of this scale there is the potential for costs to spiral.

Solution
Adopt a BIM strategy approach throughout the project lifecycle to reduce risks, save time, control cost, and increase ROI.

Using BIM processes for the planning, design, construction, and operation of the facility resulted in a model that is a data-rich, object-oriented, intelligent, and parametric digital representation of the project. Users can extract the views and data they need and analyze it to inform decision making and improve project procedures.







Façade Clash Detection

With the façade cladding covering 200,000 square meters, detecting and resolving clashes earlier in the process had significant effects on ROI.

Using AECOsim Building Designer and Bentley Navigator, the team could pull data directly from files in ProjectWise and perform automated clash detection in the model before construction began. Resolving clashes between the façade and other disciplines saved the team USD 1 million and 51,000 man hours.

Tower Crane Coordination

A logistics study indicated that five extra tower cranes would need to be purchased for 12 months. Before going ahead with this, the team used a 4D model to validate the study and discovered that just 20% of the new cranes' capacity would actually be used throughout the year. With the new information from the model the team decided to use existing cranes, saving USD 500,000 in just this one area.

Consolidated Contractors Company used Bentley's comprehensive software solutions for its collaborative design and multi-discipline engineering, construction, and delivery of the building project. Bentley's solutions are interoperable and support Bentley's i-model format, which the team uses to share data and exchange information between other applications and with project stakeholders. The team uses ProjectWise to manage all project information and keep it secure.

Lessons Learned

- Establish standards and protocols
- Create a single platform where all stakeholders can access up-to-date information in a secure location.
- Ensure this platform is scalable as your project and team expands.
- Solve interoperability issues up front by thoroughly documenting the graphic and data exchange process for each discipline
- Structure your asset data correctly. File naming, object naming, and asset tagging are key to success. Make sure that your object naming and asset tagging convention meet all system requirements for optimum integration of project control, engineering, operation and maintenance, and facility management.
- Use one robust system to manage all data, information, and models and to communicate with the entire team.

Bentley Applications Used

- AECOsim Building Designer
- ProjectWise
- InRoads
- Bentley Navigator
- MicroStation

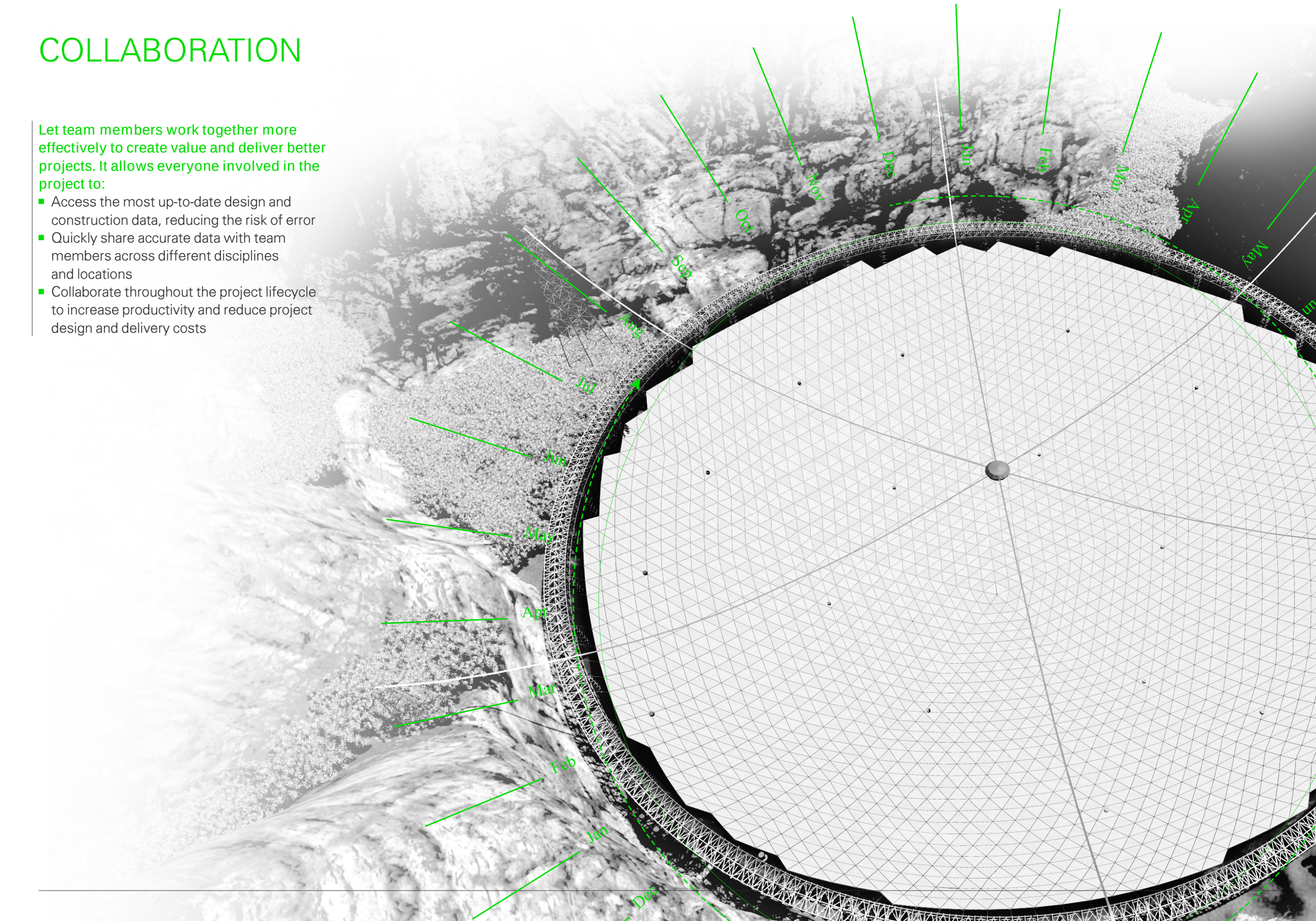
"I'd describe Bentley solutions for BIM in five words: robust, scalable, integrated, customizable, and collaborative. The quantifiable results validate why we keep investing in Bentley's BIM solutions."

Issam El-Absi, Engineering Project BIM Manager,
Consolidated Contractors Company

COLLABORATION

Let team members work together more effectively to create value and deliver better projects. It allows everyone involved in the project to:

- Access the most up-to-date design and construction data, reducing the risk of error
- Quickly share accurate data with team members across different disciplines and locations
- Collaborate throughout the project lifecycle to increase productivity and reduce project design and delivery costs



FAST
(FIVE HUNDRED METER APERTURE SPHERICAL TELESCOPE)

Location
Karst, Guizhou, China

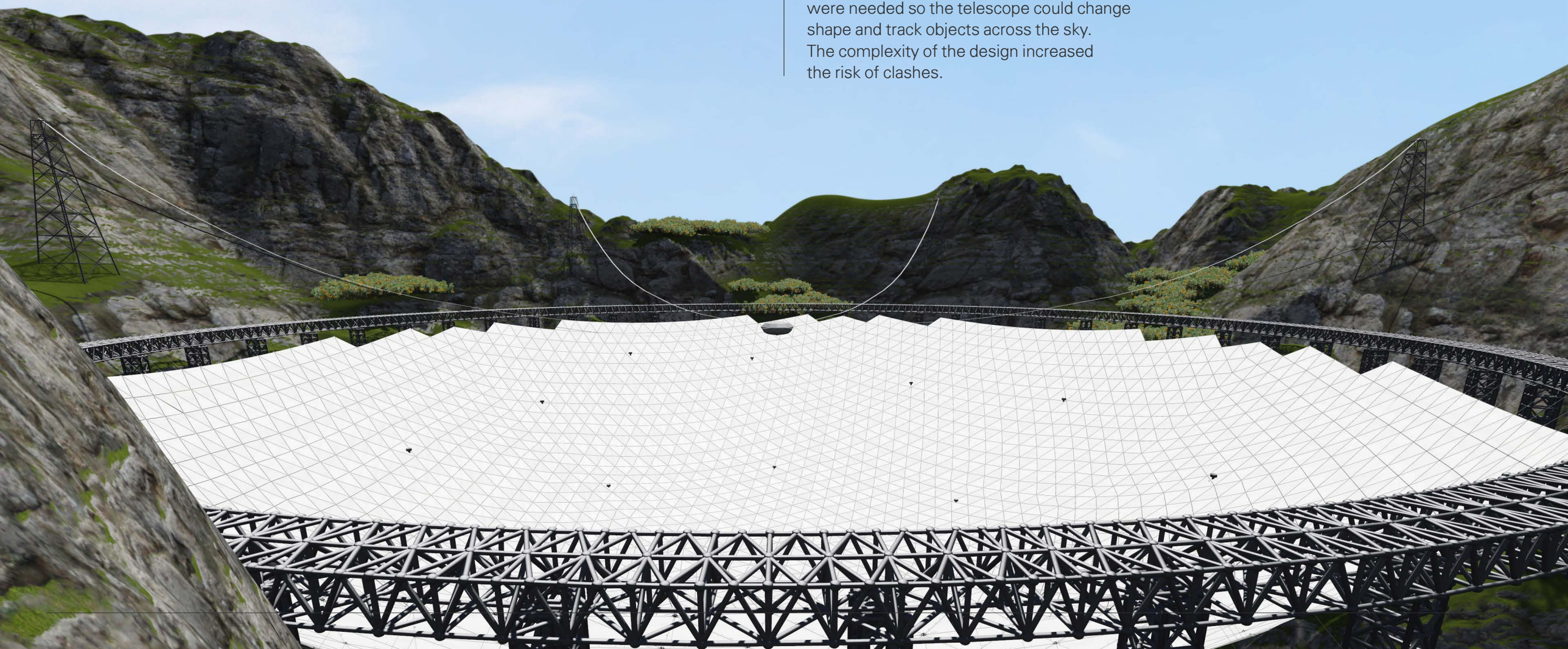
Organization
- Beijing Building Construction Research Insitute Co. Ltd.
- Beijing Insititute of Architectural Design
- National Astronomical Observatories
- Chinese Academy of Sciences

Project Cost
CNY 20 billion

Aim
Design and build the largest and most sensitive radio telescope in the world.

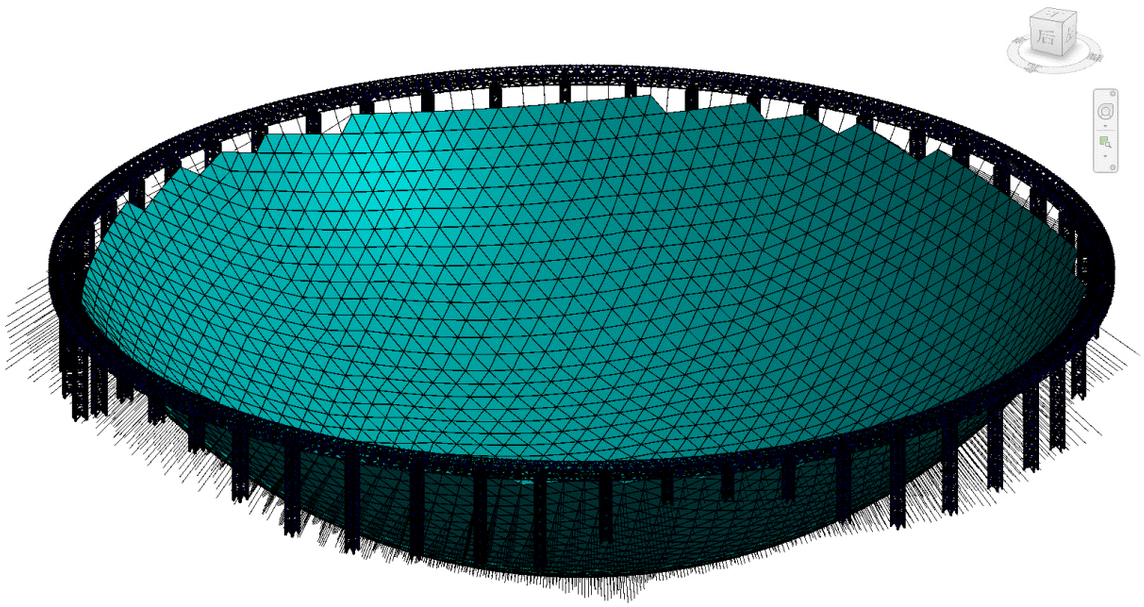
Challenges
- With 200 designers from across China working on the project, the risk of miscommunication was huge.
- 500 meters in diameter and covering an area the size of 30 football pitches, the scale of the telescope was a design and construction challenge in itself.
- As a scientific instrument, the telescope needed to be extremely accurate: some components had a tolerance of just 1millimeter.
- 4,600 reflective panels and 2,300 nodes were needed so the telescope could change shape and track objects across the sky. The complexity of the design increased the risk of clashes.

Solution
Implement a BIM methodology across the whole project from site selection, to design and construction. Use a common data environment to make it easy for designers across all disciplines to quickly exchange accurate information.



"Bentley's flexible design and project management software provided a foundation for FAST's detailed design and construction."

Liu Zhansheng, BIM Director,
Beijing Building Construction Research Institute Co., Ltd.



Telescope Design

Almost 200 designers were involved in designing the telescope so there was a huge risk of miscommunication, clashes, and inaccuracies.

Using ProjectWise as the single collaboration platform to exchange accurate information ensured that the design intent of different disciplines could be understood by everyone instantly, making the design process more flexible and efficient. By working collaboratively with 3D models, the team completed the design in three years rather than the anticipated five years and the design error rate was reduced by 90%. Using Bentley Navigator for clash detection meant the design team could quickly discover and resolve over 500 clash points before construction even began. By working in a multi-discipline, collaborative working environment, the team managed to reduce risks by 85%.

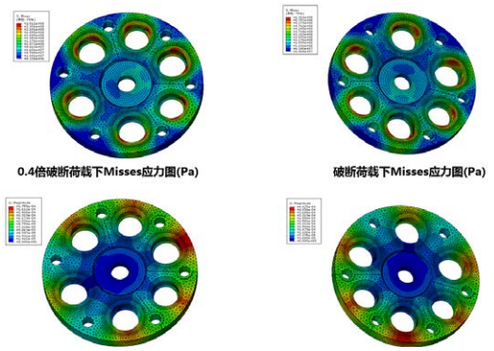
By applying specifications to standardize the design process across the project, the FAST team saved 1,300 man-days on design modifications alone, over 40 -man-days on model reviews and 400 man-days on field error handling, saving CNY 3.2 million.

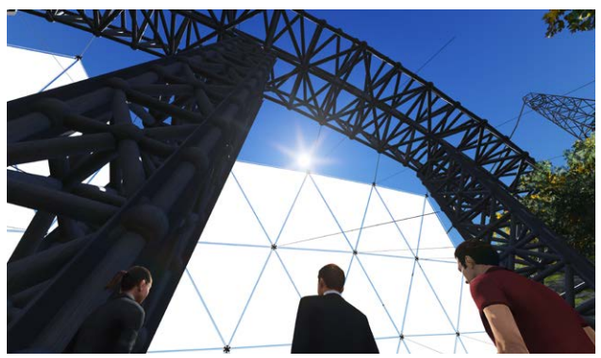
Lessons Learned

- Ensure the project team complies with BIM standards, libraries, and methodologies to achieve a high level of collaboration.
- Use a common data environment for project information and collaboration, which can support your distributed teams and workflows, as well as industry best practices.
- All applications need to work in an open, flexible, and interoperable project environment.

Bentley Applications Used

- AECOsim Building Designer
- MicroStation
- Bentley Navigator
- ProjectWise
- ProSteel





RISK REDUCTION

Resolve problems and eliminate risks before they happen:

- Create a controlled virtual environment that global teams can use to access accurate information and through which office and field staff connect during construction to reduce the risk of inaccuracies and miscommunication
- Specify standards to ensure all design offices and site personnel use common data definitions across disciplines
- Establish a co-ordination and clash detection process to minimize errors
- Quickly identify, model, and verify all components during the modeling process to avoid errors
- Detect clashes during the design phase, before the build begins
- Perform construction sequencing through various option engineering exercises throughout design and use visualization tools to identify optimum solution

SKYWAY WASTEWATER TREATMENT PLANT EXPANSION

Location
Burlington, Ontario, Canada

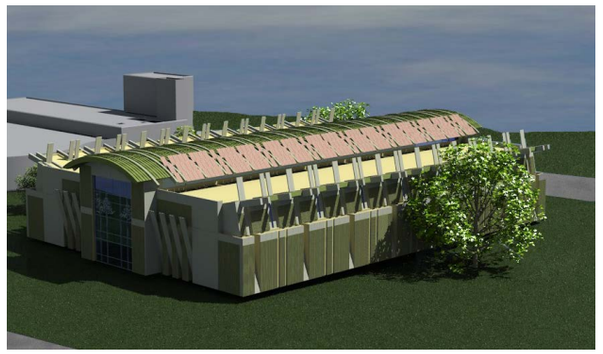
Organization
CH2M

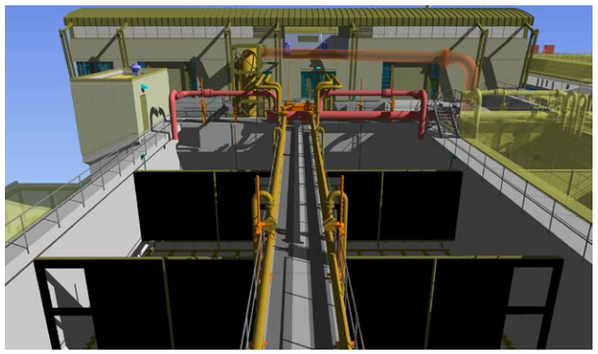
Project Cost
CAD 158 million

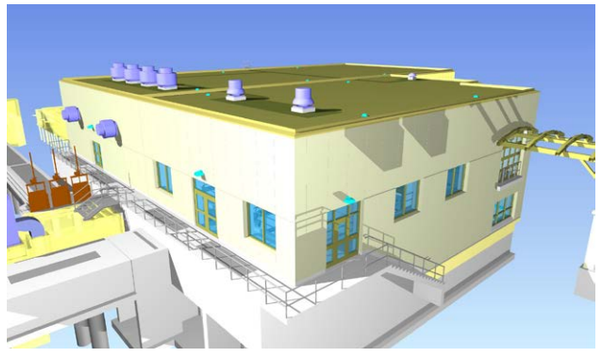
Aim
Expand a wastewater treatment plant while continuing to supply 180,000 people with clean water.

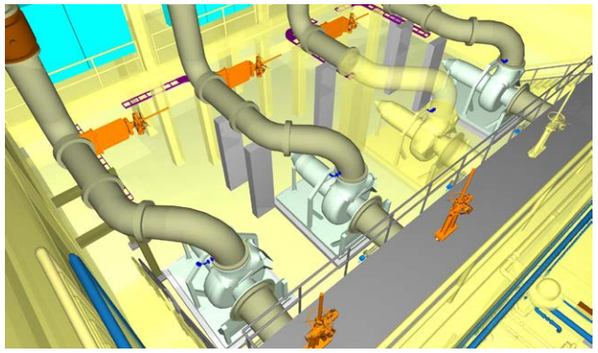
Challenges
- Keeping the plant running during the expansion made coordinating the project more challenging.
- Team members were based in 10 global offices, from Canada and the United States to Australia, which increased the risk of miscommunication.
- The original plant dated to 1961, with documents and drawings spanning almost 50 years, making inaccuracies more likely.

Solution
Implement a BIM strategy for the project and produce data-rich intelligent models to ensure seamless integration. Use a single collaboration environment to improve information sharing, communication and minimize inaccuracies and risks.









"Bentley's integrated tools, ProjectWise collaboration environment suite, and commitment to lifecycle data use have empowered CH2M to achieve consistent authoring of plant, civil, and building information models. This empowers us to develop and validate content from everywhere across the globe, whether in office or on site, from a single source of truth in a consistent manner."

Hinesh Mistry, Water Global Technical Leader (GTL) – BIM, CH2M

Phase II Expansion

The team used Bentley's integrated modeling tools to create information-rich models of the existing plant and the new design, which reduced coordination time by 50% and reduced time spent generating quantities by 75%. By using ProjectWise, the team could collaborate with team members in locations around the world while also reducing the time and cost of modeling the existing plant by 25%.

The team used tablets along with ProjectWise and Bentley Navigator mobile apps to allow them to continue to work with project data while on site for field verification, improving accuracy and saving time. By using tablets to deliver entire sets of drawings to the client, the team saved approximately CAD 10,000 on reproduction and delivery alone.

The biggest money saver, installing a temporary waste thickener, was visualized using Bentley Navigator, saving the client an estimated CAD 1 million, by allowing the plant to remain partially in service.

Bentley's integrated suite of tools ensured interoperability between building, civil, and plant disciplines, so the team was able to develop the various facility models and overall site model quickly, and to represent all assets in full. Following the expansion, access to plant data is instant, and the data is a true representation of the as-built. This saves a huge amount of time from an operational perspective.

Lessons Learned

- Develop a BIM execution plan to define expectations clearly with the client, including the ultimate project goal, so they can use the information stored in the models for operations and maintenance.
- Create a single collaboration environment and use it to share information quickly throughout the project lifecycle.
- Maintain consistency across the project so that models share a common data definition.
- Let the client interact with the models, drawings, and specifications both during design and throughout construction to optimize decisions and reduce risk.

Bentley Applications Used

- AECOsim Building Designer
- OpenPlant PowerPID
- Bentley Raceway and Cable Management
- InRoads
- MicroStation
- Bentley Navigator
- ProjectWise

BIM ADVANCEMENTS MAKE A DIFFERENCE

The benefits of adopting a BIM process are becoming impossible to ignore, and they are benefits you can experience for projects of all types and sizes. Organizations who embrace a BIM methodology will have the edge against their competitors.

People and Process

To work well, project team members must collaborate closely and exchange information and data that meet the same standards. The best results are achieved when everyone across your organization, and all stakeholder organizations, understand and embrace common processes.

BIM is a process, so introducing new software is not enough. To change your processes you need to introduce new skills and knowledge into your organization. Your team needs to understand not only how the new processes work, but also the reason behind the process and the benefits they will bring.

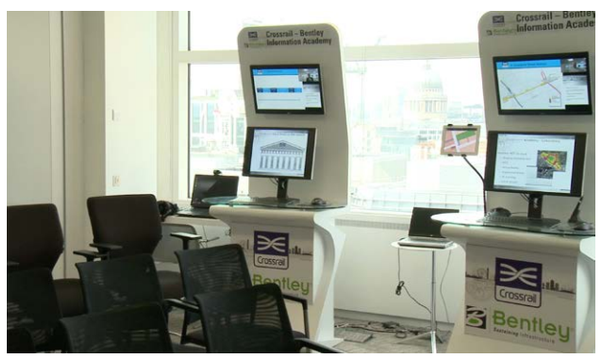
The BIM Advancement Academy

Achieving change can be easier said than done. That's why we have set up the BIM Advancement Academy program. The Academy works with organizations at all levels of the industry to educate their staff and the entire supply chain about BIM workflows and give them the skills and knowledge they need to deliver world-class projects.

What we teach at the Academy can be specific to your project. The industry standards and processes that form the basis of the curriculum (i.e, BS 1192 and PAS 1192) were sponsored by the UK BIM Task Group. By creating a replica environment of your systems and processes, we can show you the best way to work, and how to get the people in your organization ready to execute their projects. This means everyone involved in the project will be better informed and will understand the importance of BIM processes for the project.

The Bentley Institute
Bentley Institute offers professional training to help your staff develop their skills. Our team of domain experts together with our learning program can give you greater confidence to implement your BIM execution plan successfully.

To find out more about the BIM Advancement Academy and how we can help you make significant changes in your processes and standards, go to www.bentley.com/BIM.

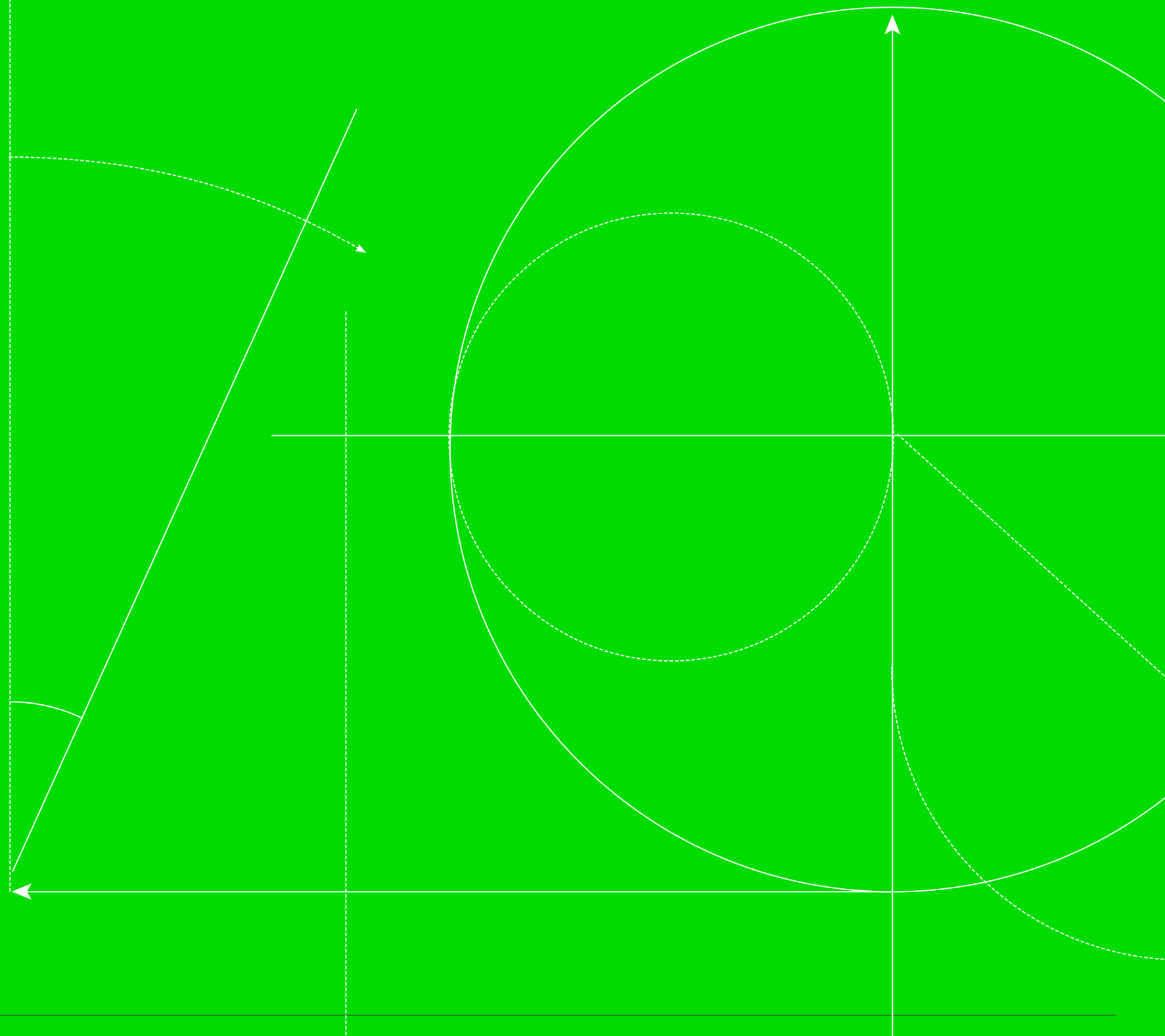


USEFUL RESOURCES

- **BIM Task Group**
  www.bimtaskgroup.org
- **BSI**
  www.bsigroup.com
- **COMIT**
  www.comit.org.uk

CONTACT

www.bentley.com/BIM



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Sustaining Infrastructure