Whitepaper

Digital Engineering: Building Reality

GeoSLAM.tech

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Chapter 1: Introduction

The next stage in the digital revolution has begun, characterised by a fusion of technologies that is blurring the lines between the physical, digital and human world. The possibilities of billions of people and devices continuously and transparently connected, with unprecedented processing power, storage capacity, and access to knowledge, are unlimited. And these possibilities will be multiplied by emerging technology breakthroughs in fields such as artificial intelligence, robotics, the Internet of Things, autonomous vehicles, digital twinning, 3D printing, nanotechnology, biotechnology, materials science, energy storage and quantum computing.[1]

Digital technology is changing the way we design, construct and look after our infrastructure. The fourth industrial revolution has already transformed retailing, publishing, travel and financial services. Digital agriculture is being driven by next generation satellite systems, driverless tractors and the Internet of Things, enabling massive agriculture productivity growth and new business opportunities.

The insurance industry, once 95% paper is now 95% electronic. Digital insurers embracing big data analytics, digitising distribution and operations are now forging ahead and reinventing customer engagement models.

The engineering and construction sector has been slower to adopt and adapt to modern technologies than other global sectors. While innovation has occurred to some extent on the enterprise or company level, overall productivity in the sector has remained nearly flat for the last 50 years.[2]

However, with the global construction sector forecast to grow by up to 70% by 2025[3], it has a bright future ahead. But to capitalise on this opportunity, leaders in this field will need to reach beyond traditional tools, and embrace not only cutting-edge technology, but also the mindset and approach to collaborate. **The ones who embrace digital engineering will not only survive, but thrive.**

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The future is already here - it is just not very evenly distributed.

William Gibson, writer

Chapter 2:
A quantum leap in technology for the construction industry

Digitalisation – the development and deployment of digital technologies and processes – is key to transforming the engineering and construction industry and moving it into the fourth industrial revolution. Innovations of this kind enable new functionalities along the entire value chain, from the early design phase to the very end of an asset's lifecycle at the demolition phase. New digital technologies such as Building Information Modelling (BIM), wireless sensing, and 3D printing have begun transforming the way that infrastructure, real estate, and other built assets can be designed, constructed and managed.

BIM is gaining currency as a platform for central integrated design, modelling, planning and collaboration. It provides all stakeholders (architects, surveyors, engineers, building owners, facility managers etc.) with a 3D digital representation - "the digital twin" - of a building's characteristics – throughout its lifecycle.

Sitting at the heart of BIM is digital technology which extends 2D technical drawings into 3D virtual information models, with project management and visualisation tools. This means that spatial relationships, light analysis, geographic information, and quantities and properties of building components can be identified. The benefits are potentially huge: greater predictability of building performance, price and programme. Stakeholders in the engineering lifecycle that embrace digital technologies such as BIM can become leaders in their field. Otherwise, they risk losing out competitively.

The ongoing transformation of the construction industry will rely increasingly on BIM and other digital tools. Many national governments - including of the UK, USA and Australia - have already acknowledged the value of BIM and have begun to mandate digital modelling in the design phase of large construction projects.

However, research into BIM adoption in the UK, suggests just over half construction professionals use BIM.[4] And in only equating BIM as a synonym for 3D drawings, professionals are missing out on the potentially significant benefits that digital engineering can offer.

But this is about to change and the key is digitalisation. The 3D spatial information model is the solid foundation and coupling the complex, data-rich technology along with drones, 3D augmented reality, ubiquitous connectivity and most importantly, a collaborative way of working, will unlock the true value of digital engineering. Digital engineering isn't only about creating models. It's about unlocking intelligence, creating data and a platform for true project collaboration that is set to be the building block for 21st century construction.

"Building Information Modelling (BIM) is changing the UK construction industry – a vitally important sector that employs more than three million people and in 2010 delivered £107billion to the UK economy. Over the next decade this technology will combine with the internet of things (providing sensors and other information), advanced data analytics and the digital economy to enable us to plan new infrastructure more effectively, build it at lower cost and operate and maintain it more efficiently. Above all, it will enable citizens to make better use of the infrastructure we already have."

HM Government - Digital Built Britain

Chapter 3:
The benefits of digital engineering

More and more construction projects are incorporating systems of digital sensors, intelligent machines, mobile devices, and new software applications increasingly integrated with a central platform of BIM. Technological advances are now revolutionising almost all points in the lifecycle of a built asset, from conceptualisation to demolition. This image from GeoEnable sets out the whole lifecycle of a construction asset, with estimated timelines.

When applied at the very earliest stages of a project, digital engineering not only facilitates better design but helps identify and eliminate risks that might arise later down the line – offering greater predictability of building performance, price and programme. And with increased predictability, comes increased confidence. Other significant benefits include:

1 Save money - unmitigated risks in engineering and construction projects lead to schedule delays, cost overruns, and in the worst-case scenarios, disputes and claims. Construction firms experience delays on a quarter of their projects, with nearly one fifth of projects going over budget[5] and costing the USA alone, over $120 billion annually.[6] During the design and engineering phase, digital engineering identifies potential design and constructability issues up front, thereby averting costly corrective rework and enabling real-time project monitoring. It also improves the tendering process by making the information more transparent and accessible. This potentially de-risks the large contingency funds which historically have been locked up; a key driver for the UK Government. Research suggests that over 57% of construction engineers believe BIM will help bring about a 50% reduction in the time from inception to completion for new-build and refurbished projects,[4] resulting in significant cost savings throughout the industry.

2 Support the full lifecycle of the asset – digital engineering doesn't stop once construction starts. In fact, we now have the capacity to go beyond the delivery phase, and support the full lifecycle of the asset through the constant monitoring and update of the digital twin, and enabling a seamless flow of information across different construction phases and stakeholders. Continuous monitoring of the project progression can take place with weekly, or even daily, 3D scans of the site providing real-time information for all project stakeholders. This improves the handover between construction and operations and with a digital format, maintenance can be planned and predicted even before the asset is built. For example, using digital engineering we can predict the real use of energy and enable facilities management systems to streamline building services and maintenance. Facility managers can reorder a damaged window by going to a virtual version of the room and clicking on the finish, or trace a faulty electrical relay through all building management systems and interrogate it.

Case Study: Creating a real-time digital twin of a hundred-year-old school, only possible through digital engineering.

Transforming an ageing school in the Jazz District of Kansas City to a community arts centre required the power of today's real-time technology. The building, built in 1905 and renovated in 1922 due to overcrowding, has had several more developments to it over the years. For any plans to be approved on the site of the Attucks School, the commission needed substantial and comprehensive drawings – materials, floor plans, site drawings and elevations. But with several hazards identified - visible deterioration in the wood floorings, ceiling collapses, and air quality conditions including asbestos – a fast, accurate and safe survey technique was required. Civil engineering firm, BHC Rhodes, embarked upon the complex task of a 3D Revit BIM using GeoSLAM technology. Lightweight, handheld scanners, built for difficult to access spaces, were used to scan the property in only 4.5 hours, recording more than 43,000 measurements per second. A BIM model was provided two weeks earlier than expected providing a comprehensive picture of the asset. Only with these modern tools could a real-time digital twin of the ageing building be created quickly, and safely.

"Digital engineering is the transformation from analogue to digital for the engineering and construction sector and represents the evolution of BIM. Without digital technology, this would not be possible, but it goes further than this and the success depends on a harmonious blend of people, process and technology working together."

Steven Eglinton, Director, GeoEnable

3 Perfect the model virtually – today, architects and engineers face daunting challenges: structures, designs and workflows are becoming more complex, while clients demand more for their money. We can now virtually test the stress factors and tolerances of an asset in multiple ways repeatedly to provide the best and safest solution to the client, before the asset is built. For off-premise construction, such as the The Leadenhall Building, where the site footprint was the building footprint, building, testing and re-testing the model virtually allows for "just-in-time" construction. Regularly using accurate and fast scanning technology on site allows you to repeatedly update the 3D model. This ensures the digital twin is always an exact mirror of the asset, and enables you to spot and correct irregularities before building work starts. Handheld mapping tools are now available for anyone to use on site and within minutes, an architect, facility manager or the building owner can quickly and accurately build a 3D map of their survey environment. For example, a foreman can carry out a weekly scan by walking the site, and within minutes automated analysis will highlight any discrepancies, saving time and money.

4 Mitigate risk – aside from time and cost overrun, there is a pressing need to identify and address health, safety and environmental risks for construction personnel, the public and future asset users much earlier in the process. "Doing more with less" is a common mantra in construction today but safety must be promoted as a core value, even in a down economy. Fortunately, today's technology can better support this risk mitigation process be it for flood assessment, fire safety tests or structural analysis. When equipped with the right technology, construction companies across the globe can work safely and more efficiently. Wearable smart sensors can track the condition of workers and drones can be used to monitor workers on sites, especially in heavily congested and remote locations.

5 Unify delivery teams – with multiple stakeholders engaged at various points of the project lifecycle, "one source of the truth" enables all parties' greater collaboration and more informed decision-making. Critical to this is having a mapping tool that accurately captures the data in 3D model form, and provides an anchor for all data extracts. In the project process, designers, architects, surveyors and engineers will all be drawing off the same data source. In some instances, you could have as many as 100 different software tools mining the data for different purposes – all looking at the same data in a different way. With a central 3D model, all stakeholders can contribute information to and extract information from the digital twin on a regular and frequent basis. Delivery teams are unified and all parties have a clear view of the end client's objectives. This not only happens at project and programme level but organisational too.

Case Study: Saving time and money with today's digital engineering tools.
Atkins is applying advanced digital and hightech solutions to high-hazard operations, such as the retrieval of radioactive waste or the transport of spent nuclear fuel. It uses 3D laser scanning and 3D cameras to provide an accurate as-built status of the asset profile up front, and thereby increases confidence in the design and facilitates delivery. Virtual reality and augmented reality help to engage stakeholders, by clarifying the design and indicating progress throughout the project's lifecycle; they also help to reduce the time that operators and surveyors have to spend in high-hazard or high-dose areas.

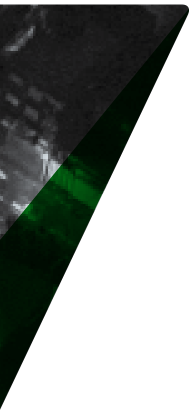
3D BIM facilitates clash detection and – by also incorporating programme details, cost constraints and asset-management information – it optimises the use of data throughout the project's lifecycle without loss, contradiction or misinterpretation. By learning from experience and implementing its solutions adeptly across the full lifecycle of the project, Atkins can achieve as much as a 20% reduction in the time needed for completing a project, and up to 16% in cost savings.[7]

“Emerging technologies are the enabler in the way we collect, use, re-use and maintain data. The end game is enabled data-driven decision making. It’s nothing short of a transformation in the way we can now manage information.”

Steven Eglinton, Director, GeoEnable

Case Study: fast and accurate scanning techniques, at the forefront of digital engineering today.

Oriel College, part of the University of Oxford, in the UK is nearly 700 years old, with around 200 rooms across five storeys, including an “island site”, accessible via tunnel. The structure has been added to over the years and no accurate floor plans or elevation drawing existed. As a world-class institute, it is occupied 24/7 and opportunities to accurately scan with minimal disruption are few. Traditional tools are not an option due to the unconventional layout and network of rooms, and a handheld, lightweight, mobile indoor mapping tool is needed. GeoSLAM’s technology is at its best in complex, enclosed, multi-level environments recording over 43,000 measurement per second. Scanning is completed in half the time as static equipment and for the first time in nearly 700 years the site has accurate 3D models representing the buildings in their truest form.[8]



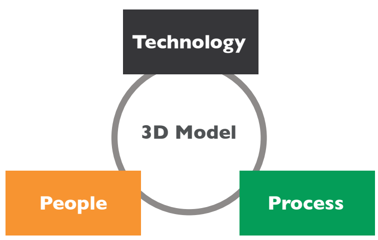
Chapter 4: The building blocks for success

The digital twin of the asset sits at the heart of digital engineering and is paramount to its success. Throughout the building lifecycle, from design to construction and maintenance, engineers and surveyors, architects and facilities managers today need to accurately capture, manage and utilise 3D spatial information. The demand for up to date, accurate 3D models is greater than ever before. Most projects now require comprehensive information to be captured inside buildings and enclosed environments, as well as in complex and difficult to access spaces where there is no GPS coverage - a capability that until recently was either too costly or simply too difficult to achieve. Engineers will often have a very limited time on site to accurately create actionable 3D models; and for on-the-job quality control they'll need to continually compare as-built models against the design plans. Access to user-friendly technology that can quickly scan multi-level environments and produce accurate and high quality 3D data can be a game-changer for engineers. With today's tools, highly detailed surveys are produced that would be almost impossible with traditional instruments and the real-time 3D information becomes the cornerstone of the asset – the "one source of the truth".

By creating a digital twin of the asset and providing a central data source, greater collaboration and more informed decision-making can take place. Using digital tools such as BIM, and aligning that data across multiple project stakeholders and project lifecycle phases provides a platform on which the model can be built. It enables smoother processes, better interoperability and improved data integrity. Digital engineering is also a key enabler for Design for Manufacturing and Assembly, driving the manufacturing process from concept to assembly sharing structured data between client, supply chain and contractor. Well managed data is of paramount importance in this process. It's just as important to protect the integrity of the data, as it is to manage its usage.

Having access to regular updates of the digital twin, means that all the project team can make better decisions. And with the technology tools available today, which are accessible and operate in all environments, access to accurate, fast and cost effective real-time 3D information is possible. Costly mistakes can be avoided as the digital data mirrors the reality, and the construction process throughout is improved.

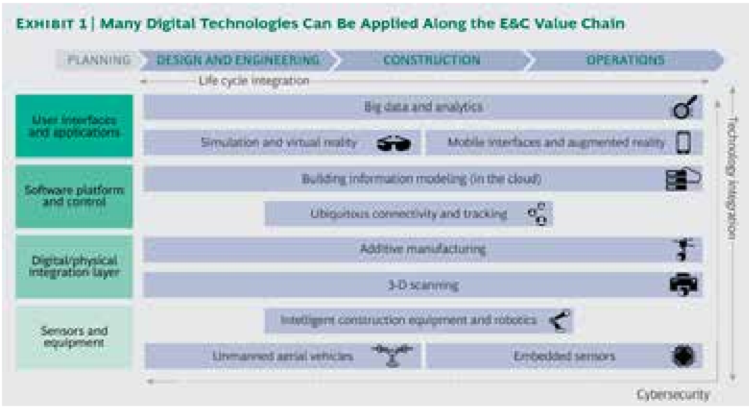
But key to achieving digital engineering excellence is having the right blend of technical and cultural platforms. The true value in digital engineering comes with a convergence of people, process and technology. Multiple stakeholders are involved in every engineering project from designers and architects, to engineers, surveyors and facilities and asset managers. An inclusive environment based on openness, cooperation and knowledge-sharing must be underpinned by consistent processes and access points, allowing everyone involved in a project to navigate freely around the model and explore the data. The silo-busting nature of digital engineering means everyone in the value chain can benefit from collaborative workflows and drive true innovation. Data-rich technology platforms, standardised ways of working and the right mindset are the building blocks that together will unlock the value.



Chapter 5:
Blueprint for the future

Full scale digitalisation in non-residential construction could, within 10 years, produce annual global cost savings of 13-21%[2]. With the global construction sector forecast to grow by up to 70% by 2025[3], this cannot be achieved by manpower alone. The technologies that will play a leading role in enabling this growth range from big data analytics, mobile connectivity and 3D augmented reality to drones and embedded sensors. This diagram from Boston Consulting Group illustrates the digital technologies that will shape the future of the engineering and construction industry.

Tools that are cost effective, easily accessible, work in all environments and quickly prove their worth will be widely adopted. For example, disruptive technology such as handheld mobile mapping tools allow



you to build highly accurate 3D models of any indoor, underground or difficult to access environment within minutes. These are lightweight, handheld and easy to use scanners that capture and model complex 3D data up to 10 times faster than traditional tools.

Tomorrow's engineer will be defined by their ability to integrate innovative engineering approaches, digital technologies and rich data. Ultimately, digital engineering will realise its full potential only if widely adopted and computerised construction is the industry norm. A fertile environment must be created in the sector. This is the responsibility of all stakeholders: government, regulators, construction companies, technology firms. And for the early adopters, speed matters.

We shape our buildings; thereafter they shape us

Winston Churchill

"Over the next decade this technology will combine with the internet of things (providing sensors and other information), advanced data analytics and the digital economy to enable us to plan new infrastructure more effectively, build it at lower cost and operate and maintain it more efficiently."

HM Government - Digital Built Britain

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