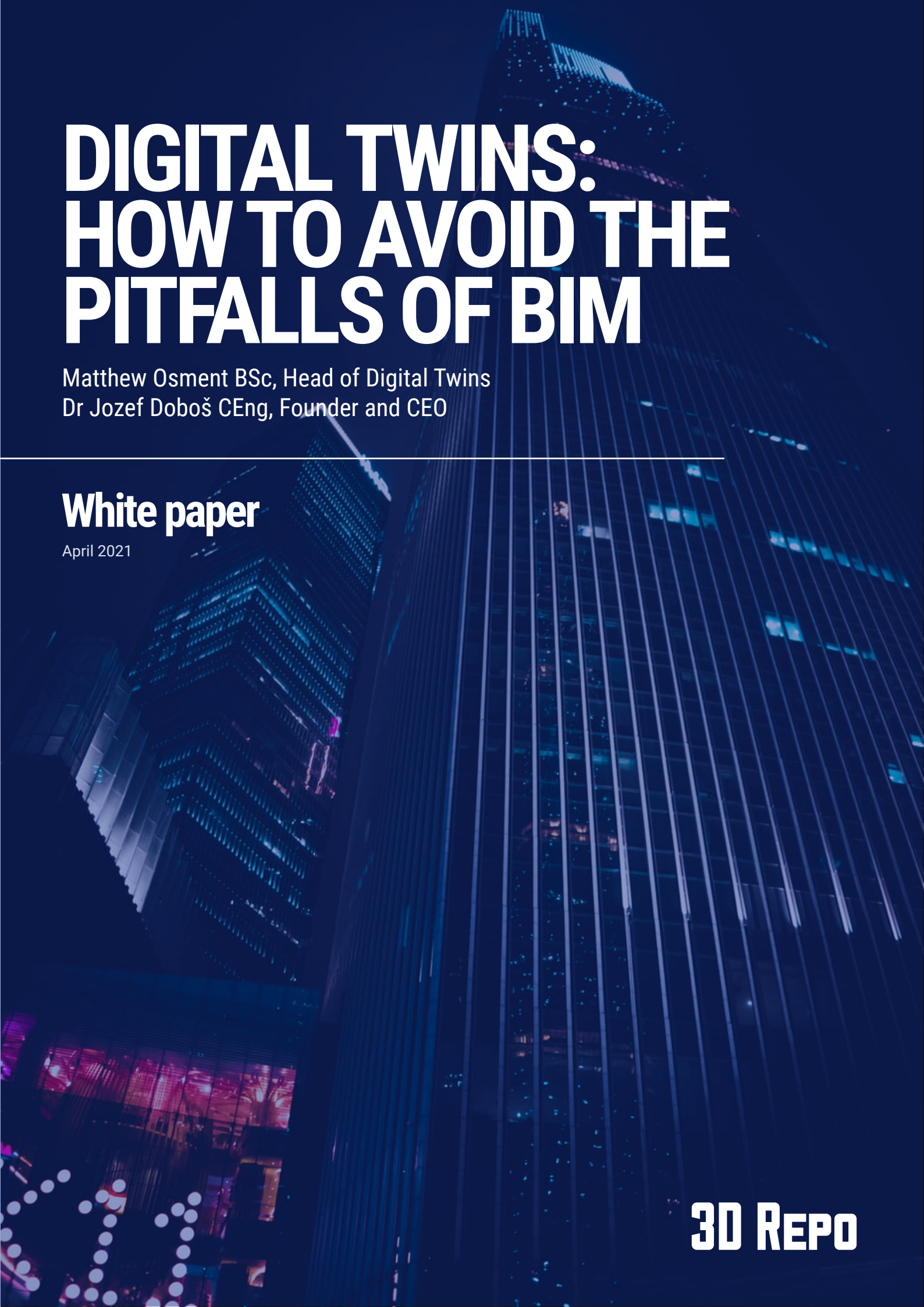

DIGITAL TWINS: HOW TO AVOID THE PITFALLS OF BIM

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White paper

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3D Repo

Foreword

Over the past decade, we have witnessed an unprecedented transformation in the Architecture, Engineering, Construction and Operation (AECO) industry in the UK but also abroad.

From the early use of collaborative 3D technologies mandated as part of the UK Government Construction Strategy in 2011[1] (put into practice in 2016) which certainly accelerated the adoption of Building Information Modelling (BIM); to the introduction and eventual fall from grace of Virtual Reality (VR)[2], the buzzwords in this industry change as frequently as the trends at London Fashion Week. The nirvana of BIM supposedly promised the now infamous 20% construction cost savings that were nowhere to be seen. Therefore, there is no surprise the level of scepticism that any such a new concept receives. Thus, to avoid similar misconceptions from the past, we have contributed to the development of the Digital Twin Toolkit[3] in order to first define what we mean by a digital twin and second to clarify the business case as well as the benefits this newly rediscovered concept brings.

This whitepaper therefore expands on the toolkit by providing advice and suggestions from our own experience and the journey of the past ten years so as to avoid the same pitfalls that BIM has led to. A client claiming they have “BIM getting delivered next Thursday” only for the team to discover it is just a computer with a pre-installed Revit is one such example.

Dr Jozef Doboš CEng
Founder and CEO, 3D Repo

Introduction

In a nutshell, Digital Twins (DTs), as the name suggests, provide a form of a digital counterpart for a physical asset. They promise to transform construction delivery and Facilities Management (FM), boosting operational productivity, quality and ultimately profitability in the process. But the clients' ambition for the technology will fall flat if important lessons are not learnt from the prolonged and often painful BIM roll out from the past decade that finally after some amount of "emotional scarring" resulted in an ISO standard[4].

Assuming you have read the Digital Twin Toolkit by Centre for Digital Built Britain available for free online:
https://digitaltwinhub.co.uk/files/file/62-digital-twin-toolkit/ and decided a DT can bring tangible commercial benefit to your organisation, the aim of this whitepaper is to then highlight the possibilities of digital twins and to debunk the myths surrounding them. It also draws on the experiences of implementing BIM while challenging the industry to avoid the same pitfalls by approaching digital twins in a radically different way.

This white paper defines:

- The status quo of digital twins and how the concept fits into today's AECO industry;
- The power of mutual understanding and agreement of what determines a digital twin;
- The advice on how to avoid the potential to overwhelm and overcomplicate;
- The questions on how to determine whether tools you need are right in front of you;
- The misunderstanding of old vs new data;
- The benefits of implementing 4D BIM for the purposes of DTs;
- The need to streamline coordination between all parties for a DT to succeed.

Digital twins in 2021

Industry 4.0 has promised us a bright digital future where disruptive technologies and processes, such as machine learning (understand statistical regression), data analytics, robotics, and the Internet of Things (IoT), deliver greater accuracy, productivity, collaboration, and ultimately better performing built environment.

Among the plethora of innovations, digital twins are generating a huge interest and construction teams and their supply chains are already moving to harness their potential.

The ability to run a virtual replica of a built asset, brought to life by real-time data, offers short and long-term benefits across the entire asset lifecycle. It can underpin more effective process execution and supercharge ongoing operations and maintenance. An important aspect, however, is the feedback loop whereby the users take action based on the readings from such a DT, otherwise all they end up having is a virtual dashboard and there are certainly many to choose from.

A major misconception is that DTs are only suitable for asset operation and facilities management. Yet, twins can also test construction sequencing and logistics scenarios, verify the as-built situation, or run 'what if' simulations using live data from building sensors to optimise performance and sustainability. All of this can vastly reduce the errors and inconsistencies associated with more traditional methods of information management in construction.

In our experience, twins tend to rise from the foundations of BIM, indeed 3D models developed for construction can form the backbone of a virtual replica even though it shall be noted that a 3D model is not a necessary component of a DT. But if they do exist, professionals can overcome the technical and cultural barriers that have prevented BIM from reaching its full potential beyond the application of design and construction.

As mentioned in the foreword, the UK Government mandated the use of BIM[5] on public projects back in 2011, and although adoption has gradually grown (73% are now aware of, and using it according to the 2020 NBS survey[6]) many teams are ill at ease with the whole process.

The inconsistent quality of BIM information and data exchange throughout design and construction has undoubtedly limited its efficacy. For a long time, BIM was considered a type of software, rather than an overarching approach and a way of thinking. Client support was a crucial driver for change, but many remained in the dark on its value. All these issues will also prevent digital twins from becoming the game changer, too.

Doublespeak

Emerging technologies are driving interest in digital twins, which are actively being promoted by major UK organisations including the National Digital Twin programme at Centre for Digital Built Britain[7]; the National Infrastructure Commission[8]; the Institution of Engineering and Technology[9]; the Institution of Civil Engineers[10] and the Open Data Institute[11]. Further afield, there is also the US-based Digital Twin Consortium[12] and from private companies pushing the boundaries we shall also highlight Epic Games, the creators of Unreal Engine[13].

Over 500 urban digital twins are likely to be deployed by 2025, up from just a handful in 2019, according to ABI Research[14].

Interestingly, the already existing technology can underpin many benefits during CAPEX phases of a project, for example virtual scenarios for construction sequencing and logistics can be run risk-free, helping familiarise workers with tasks and prevent costly re-works. Interconnected 3D models can be further optimised for criteria such as passenger flows, access to daylight or utilities, as well as resilience against extreme weather conditions including flooding. The same solutions used for predictive analytics can be further improved by feeding in live data upon delivery which further improves the underlying simulation models.

During OPEX phases, DTs can assume the role of a virtual operating system, using data-driven decisions to predict repair and maintenance activities; or to simulate scenarios for energy, lighting, occupancy, etc., in a bid to reduce bills or improve sustainable performance and productivity. For instance, our partner SPI used predictive analytics during construction of the King's Cross station remodelling to determine a new improved schedule of switch points maintenance[15].

Although most stakeholders are now onboard for the digital twin ride, disagreement on what a twin should include threatens to undermine their effective development and the value add[16].

Similar confusing messages plagued BIM throughout its development. To this day, many practitioners believe the term to refer to 3D modelling, rather than the data management and cross-party collaboration it actually is.

The Gemini Principles[17] define a set of core values that built environment professionals should consider when contributing to the development of a national digital twin, which can be defined as *"a realistic digital representation of assets, processes or systems in the built or natural environment"*[18].

It is not that complicated

More than a digital model, what distinguishes a digital twin from a simple dashboard or a simulation is the connection to its physical counterpart , where 'connection' means some form of a relationship or an association requiring a feedback loop.

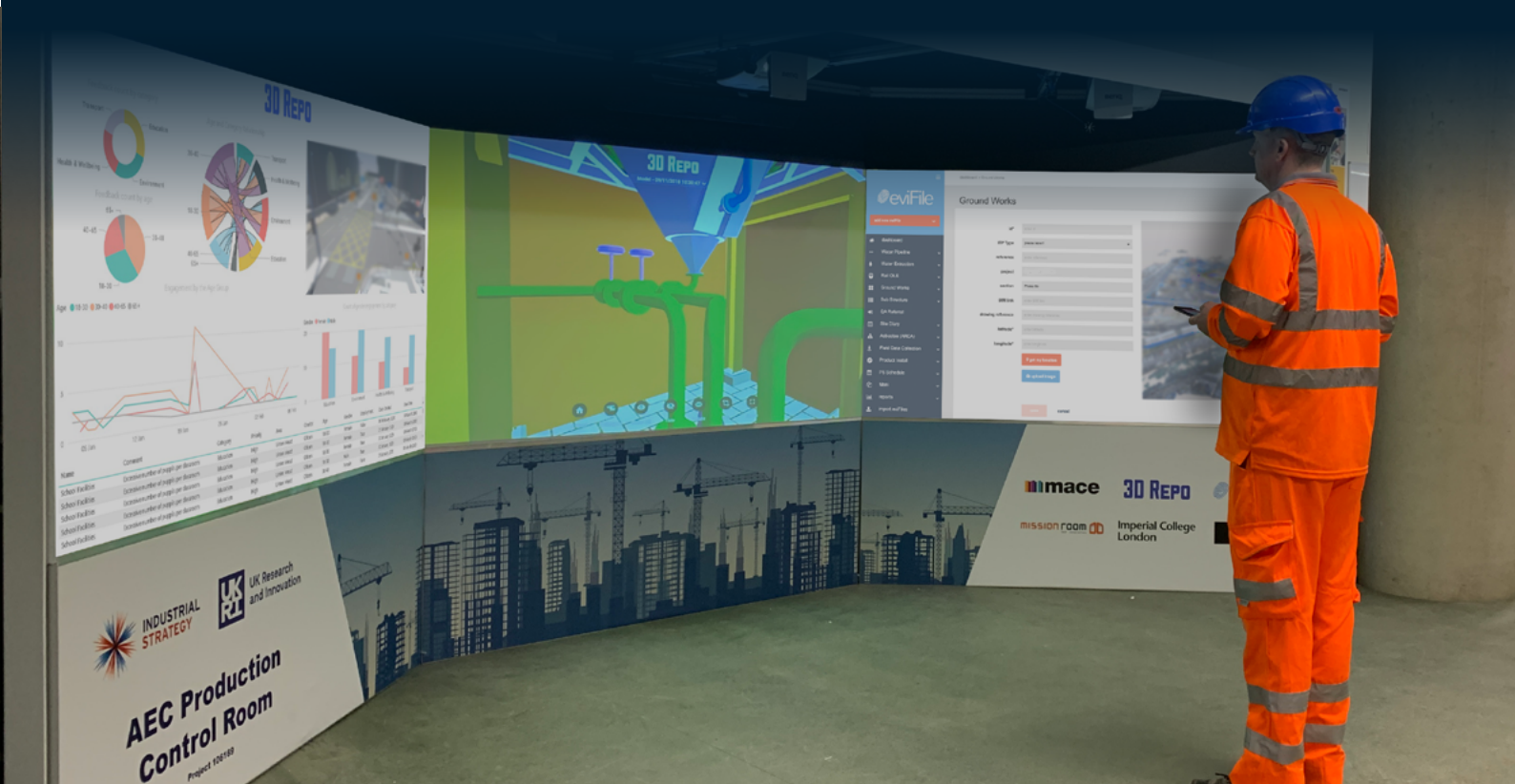
What many people do not appreciate is that the concept of digital twins can equally be applied to construction itself. Our partnership with Mace, we have developed AEC Control Rooms whereby real-time site data is being projected into a live NASA-style control room for the engineers and construction workers to tightly manage the process and make informed decisions with the highest possible accuracy[19].

Ultimately, the transformative potential of twins lies in their ability to connect disjointed data sources together in order to provide deeper insights across a wider context. A virtual replica of a site can provide a 'single source of the truth', where all design-build-operate data can be accessed, viewed and acted upon.

In the future, entire ecosystems of digital twins will need to be connect and securely share data to provide a holistic view at the national level.

The UK Government is currently laying the groundwork for a National Digital Twin, made up of thousands of inter-connected twins that feed into one another to aid strategic planning. An early example of this effort is our work with the Greater London Authority (GLA) on developing an open source web-based tool for virtual planning called PlanBase[20].

Since no new asset can be built without a planning permission, over time such a system will hold the most accurate virtual twin of literally the whole built environment. As a first step towards a more connected ecosystem, in early 2021 GLA released the Planning London Datahub[21].



Start small and build up

Grand notions of monolithic interconnected models are inspiring, but also daunting for the majority of consultants or contractors who want to get a foothold on the digital twin ladder.

Similar concerns held back the uptake of BIM as potential users were put off by the idea of complex software set-ups and the belief they had to implement the full government Level 2 BIM standard. For most, the digital upskilling and the huge up-front costs were simply too much to bear. Yet, we also worked closely with progressive clients such as Canary Wharf Group and their own Canary Wharf Contractors who realised the potential and benefit of BIM despite not being interested in delivering any publicly funded projects[22].

We see the same situation with digital twins, all it takes is a progressive view and the appreciation for the promised return on investment. It doesn't have to be this complicated, in reality taking small steps with digital twins and gradually scaling them up is the most suitable approach that can provide very positive outcomes without huge investment. Fortunately, one does not need all the information to be available from the onset. In fact, we believe that any digital twin needs to be built over time by feeding in more data inputs, observing their benefits and reiterating. This way, the benefits can be demonstrated early on without the often scary up-front costs that an all singing, all dancing system would likely demand.

The key is to understand this is a process and so it will never feel truly complete. In fact, the digital twin will continue to evolve throughout the asset's lifetime as real-time usage data is continually added and modified over time.

Grow and evolve

Think of a DT as a work in progress for which possibilities can grow in line with clients' needs. As technology and techniques improve, more complete and connected twins will emerge. And by more complete we do not imply more complicated nor necessarily photorealistic, although the promise of building the Metaverse which blends the virtual with the real is certainly very compelling[23].

Most companies already have the tools at their disposal to build their own digital twins using existing software, it is simply just a matter of taking ownership and investigating the time needed to integrate them.

Most popular packages include Application Programming Interfaces (APIs) that define interactions between multiple software or mixed software-hardware platforms.

We consider APIs[24] as crucial to helping the industry truly collaborate and seamlessly access data in the digital realm, instead of managing data through closed 'containers' and proprietary systems.

3D Repo's open APIs give users access to a wealth of data stored on its servers which led to a growing list of integrations[25] with the likes of Opentext, Asite, Procore, Luminova, Dynamo, and most recently Power BI.

The Power BI[26] integration exploits 3D Repo's free-to-download embeddable viewer, where users can pull models from software like Autodesk Revit, Navis, Civils 3D, or Bentley Microstation into interactive dashboards on the web.

From such dashboard, meta-data such as issues, risks, and groups can be cross-referenced with external data sources like production status, IoT sensory readings, real-time site deliveries, weather forecast, CCTV cameras, etc. This form of data aggregation is a digital twin in all but name, bringing together disparate data sets in a way that is not possible elsewhere.

Fortunately, not everyone needs to be a computer wizard to be able to benefit from this technology. 3D Repo also fully supports and integrates with No Code platforms such as Microsoft Power Apps and Power Automate so that anyone can within minutes create and data integration their specific project requires.

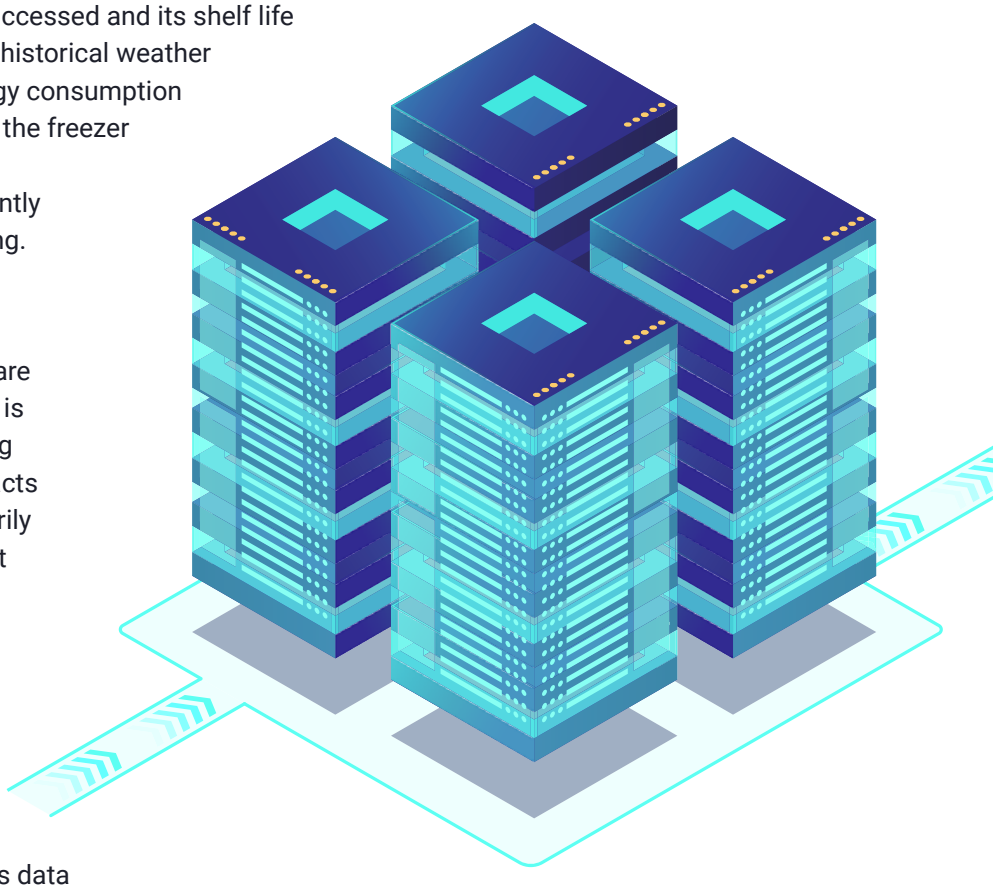
Most present day innovations are built on the successes of the past and while digital twins might seem like a separate beast altogether, they are in fact a logical extension to BIM and the data produced within.

Embracing all data

The common data format and standards already used for BIM formed the blueprint for a new Information Management Framework (IMF)[27] for digital twins to facilitate secure, resilient data sharing.

After all, we already established that the data input into BIM during the design and construction phases provides a vital jumping off point for the development of a twin. Another common misconception is that twins must be populated with new data, from sensors in buildings or external sources. Instead, the onus should be on collating and exploiting existing information, generated throughout the course of a project, in a more meaningful way.

The best way to understand data lifetime is to consider the fridge vs freezer analogy. High-frequency real-time sensory information such as temperature readings from Building Management Systems (BMS) or concrete curing on construction sites are changing relatively frequently while their usefulness for action taking is time limited. That would constitute the fridge concept in our analogy whereby the data changes frequently, is regularly accessed and its shelf life usefulness is relatively short. In contrast, historical weather recordings, site access and average energy consumption over long period of time would constitute the freezer concept. There, data is stored for archival purposes and retrieved relatively infrequently for deeper analysis or longer-term planning.



Despite widespread adoption of various BIM standards and guidance on projects, information requirements for 3D models are often not properly set and the data within is either structured inconsistently, or missing entirely, in part because of the way contracts are drawn up. These failures will necessarily limit the effectiveness of digital twins that often take the existing BIM models and build upon them.

Better due diligence on information sharing should see asset owners to demand the details of what was constructed on site, the treasure trove of as-built vs as-is information needed to run a digital twin. Gathering this data in a consistent and organised manner would avoid the extra investment needed upon project delivery.

The power of 4D BIM

Many construction and infrastructure projects are already exploiting the advantages of 4D simulation, i.e. the combination of project programme with 3D BIM so as to plan and visualise the construction sequence. This helps improve planning and communication compared to traditional Gantt charts.

However, far less well understood are the benefits of using 4D to accurately monitor progress and keep an up-to-date record of as-designed vs as-built models through frequent surveys, photogrammetry, or LiDAR etc.

Various tools such as Holobuilder can connect planned 4D models with site cameras or drones in order to highlight where work has been completed and where it is delayed against the original design. QR code scanners can also track the delivery of components and parts and upload the data into the 4D model. This system would once again constitute a construction rather than the more common operations digital twin.

Nevertheless, if all such data is pushed regularly into a digital data exchange platform like 3D Repo, it can provide an accessible record of the entire project. This not only improves visibility and cost management, if the information is structured correctly it can form the basis of a full digital twin from design to maintenance, allowing operations teams to move away from more traditional FM systems.

Data crunch

Effecti and coordinated collaboration across various system is essential to making DTs work effectively, but time and again projects have hit stumbling blocks when consultants and specialists try to exchange large 3D models, often in different formats, with heavy data payloads associated with them.

The need to repeatedly download and access large files can slow down tracking of changes across stakeholders.

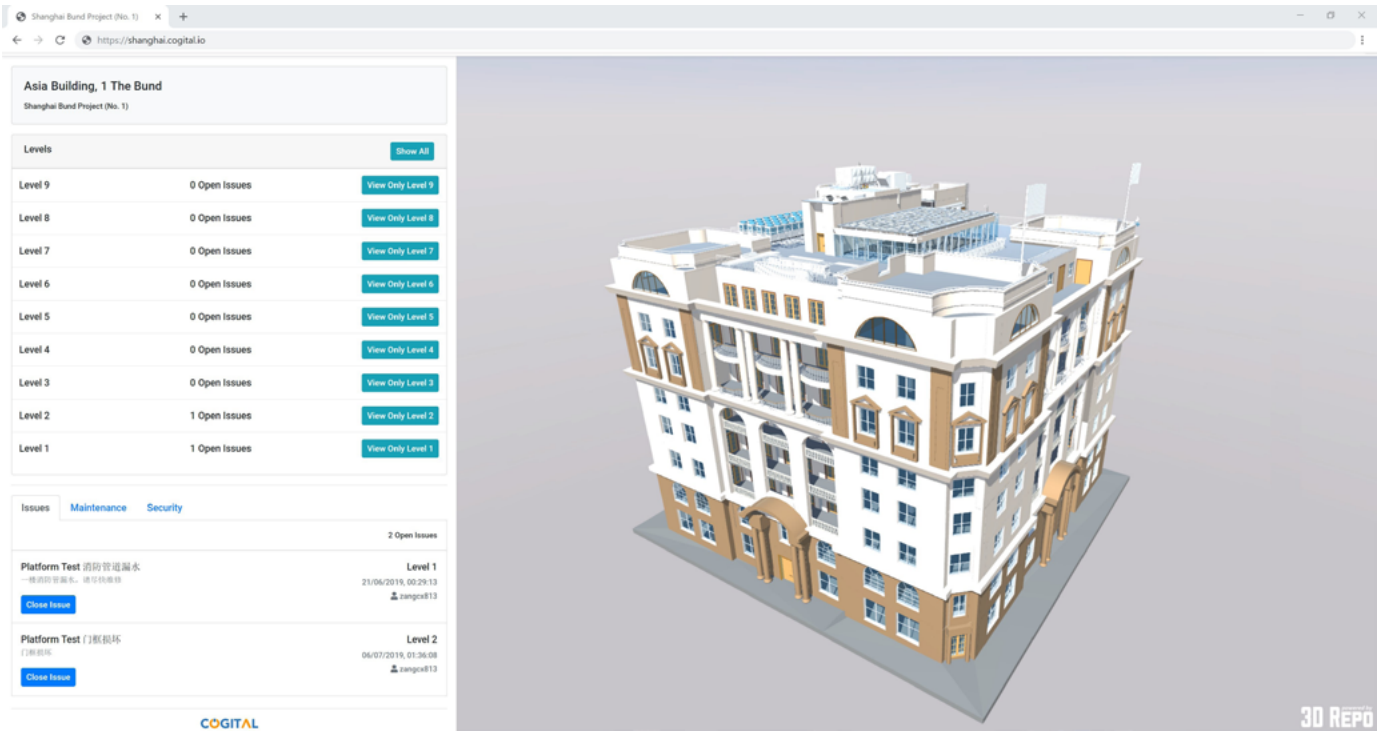
It is also essential to realise that a single digital twin does not need to hold all the data locally. Systems such as the 3D Repo platform sit in the cloud and allow anyone with an internet connection and a web-browser to log in remotely in order to interrogate their custom digital twin.

Using our embeddable 3D viewer, consultants can easily build their own client-specific digital twins in the cloud. There is no need for expensive PC h ware with powerful graphics processing, instead real-time changes are added instantaneously to create a reliable visualisation.

Most digital twins are still developed using game engines such as Unity 3D and Unreal Engine. There, the major shortcoming is that the assets are hardcoded into the game itself so as soon as the assets change, the game has to be recompiled and redistributed again.

Fortunately, 3D Repo is closely working with EPIC Games to build a new data delivery platform, combining the power of game engines with the 3D Repo's infinitely scalable cloud platform. Instead of baking all the assets into a game, these can now be streamed from the cloud thus significantly speeding up digital twin development and delivery.

This means users can log-in and seamlessly retrieve any of their assets on the fly and explore vast high lity 3D scenes in real-time. DT teams need no longer to run into a wall when trying to visualise large-scale projects using existing solutions.



The conclusion: Pairing it all up

Digital twins provide an unprecedented opportunity to transform not only operation but also the design and construction paradigm, and though the specific form and formats are yet to be fully developed, the benefits are already tangible, and the technology is there.

The creation and management of DTs extends across the entire project lifecycle, so stakeholders involved in every stage should understand the benefits and how they can contribute to the process.

Engagement of people who own and operate the assets will need to ensure that project teams appreciate what information needs to be recorded and when. Clients often look to their consultants for advice on the best way to procure built assets, and as with BIM, if they do not understand the tangible monetary as well as process value of digital twins, it will be very difficult.

With BIM, there was a certain level of consensus with resulted in the development of an ISO 19650 standard. Unfortunately, the definition of digital twins turned into the Wild West and it seems anyone who is someone has the urge to provide their own definition of what a DT should or should not comprise. Ultimately, what matters is the clear benefit and business case that each and every DT can bring to their users and that is the definition under which any sensible client should subscribe.

Digital twins transcend sectors, which m[illegible]s working collectively, through shared frameworks and ecosystems to achieve the wider social, economic and environmental benefits. If these challenges can be sufficiently met, a new era awaits, one that represents a shift to a more connected, digitally enabled world. Maybe the promise of the Metaverse can be achieved after all.

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Dr Dobos is the founder and CEO of 3D Repo, a spin-out from his doctorate in Virtual Environments, Imaging and Visualisation at University College London that was sponsored by Arup. Prior to founding 3D Repo, Dr Dobos completed his Master of Engineering in Artificial Intelligence at Imperial College London as well as Entrepreneurship at Imperial College Business School and New Venture Development at London Business School. He also works as an Expert for European Commission and sits on the Transforming Construction Advisory Board at UK Research and Innovation.

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3D Repo