

# BREAKING DOWN THE BARRIERS TO 4D ADOPTION

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With thanks to James Bowles, Founder of Freeform

**White paper**

June 2021

**3D REPO**

# Foreword

I spend a lot of my time in 4D planning meetings. The format is usually the same: a large screen, a detailed 4D construction model, and input from the team who are about to go out on site and build it. It's a simple way of working and it's incredibly effective. The 4D construction model is usually very detailed, and includes the construction sequence, access equipment, safety equipment, permanent and temporary works, and the site survey.

These sessions can be years in advance or can be on the morning of an activity that is planned to happen that same day. The type of projects span all sectors, and vary in scale from small projects to huge infrastructure programs covering 100s of kilometres and years of construction.

The result is always the same - better planning, which delivers significant improvements in safety, time, cost, waste, and collaboration. The adoption of this method of working, which can be referred to as model-based planning, visual planning, digital rehearsal, or simply '4D', is growing at an exponential rate.

The tools that we use to support this process are changing rapidly and becoming ever more flexible and useful for site teams. These sessions are becoming increasingly interactive. Soon, anyone will be able to use a mouse, pick up a game controller, move around equipment and create simple sequences of construction.

This will be a big step forward, and it's fantastic to see solutions like 3D Repo embrace 4D and pair it with features like SafetiBase. At Freeform, we're using this process on our new projects and the improvement in team planning is significant.

The site teams are the ones who build our projects, and 4D unlocks their expertise.

For more information, please visit [www.4d.construction](http://www.4d.construction), our industry group focussed on this topic.

■ **James Bowles**  
**Founder, Freeform & Chair of 4D Construction Group**



# Introduction

As the construction industry continues with its steady march towards greater digitalisation, interest in 4D is growing as it is increasingly seen as a better way to plan, explain, monitor and report on construction projects. However, despite this interest, there remains a stigma that 4D can be costly, time-consuming and difficult. While this may have been true for some of the first 4D projects to be realised, with the advent of new technologies, 4D no longer needs to be expensive or difficult.

There's also a common assumption that construction project planners need to wait until the full BIM model is completed before they can start planning in 4D. In fact, 4D planning can begin with a simple 'communication level model', and project planners, health and safety professionals, engineers and surveyors can start to reap the rewards of using 4D much earlier in the project.

This white paper aims to de-bunk some of the myths surrounding 4D adoption and demonstrates how more stakeholders can benefit from using 4D from the beginning and throughout every construction project.

## **This white paper defines:**

- Why 4D is moving into the mainstream and how to get started;
- The role of content, technology and people in implementing 4D;
- The value that 4D can bring to benefit every construction project;
- How 4D can improve health and safety, planning, communication and collaboration;
- The intersection of 4D with Modern Methods of Construction (MMC);
- The role of 4D in reducing waste and improving sustainability;
- The future of 4D.

# Digitalisation at the core

“While the volume of data relating to UK construction is rapidly increasing, it is often fragmented or not easily accessible. Improving the consistency and quality of data will be transformational in how we can deliver projects and programmes by improving safety, enabling innovation, reducing costs, and supporting more sustainable outcomes.”

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Construction Playbook, December 2020

The need for the construction industry to modernise has been long-documented. Systemic problems include a fragmented and adversarial industry; a variable health and safety record; poor quality control; an on-going skills shortage; variable costs and availability of materials; pressure on profit margins; and a cost-driven rather than a value-driven culture.

Alongside all these challenges is the urgent requirement to decarbonise the built environment to help the UK meet its net zero targets.

Central to the many changes that the construction industry needs to make is the requirement for increased digitalisation and the need to embrace new technologies.

Back in 2016, the Construction Leadership Council published the Farmer Review, *Modernise or Die*<sup>1</sup>. Written by Cast Consultancy, the high-profile report clearly outlined the changes that need to be made within the construction industry to embrace factory-based, modern methods of construction and a ‘design for manufacture and assembly’ mindset.

More recently, in December 2020 the UK Government published the Construction Playbook<sup>2</sup>. It recognised the critical importance of embracing digital technologies to enable the industry to reach its transformation goals and importantly, to address the key issues of health and safety, while also creating a sustainable industry.

# Putting the spotlight on 4D

One of the latest construction technologies to fall under the spotlight is 4D. Whether referred to as 4D BIM, 4D planning or 4D modelling, 4D is a way of bringing the 4th dimension, time, into the planning and modelling scenario.

According to the NBS, 4D BIM “adds an extra dimension of information to a project information model in the form of scheduling data.”<sup>3</sup>

Until recently, 4D has primarily been the domain of the planning department. In early 2020, research by the 4D Construction Group<sup>4</sup> found that there was little engagement with 4D by operations teams. 4D was largely seen as a planning exercise and a technical

process, and the opportunity for collaboration between teams and stakeholders was limited.

However, in recent months the broader applications of 4D have started to shift into the mainstream. And contractors are starting to realise the wider benefits of using 4D throughout the project – from reducing waste, to improving health and safety, saving time, planning better, and improving communication and collaboration.

## Case Study: Improving construction project management in a virtual 4D environment

Mace, 3D Repo, eviFile, Imperial College London, Mission Room and University College London have joined forces to create the AEC Production Control Room, funded by Innovate UK, it aims to enable more proactive project management in UK construction.

The team has built a scalable and repeatable construction management and reporting platform that will be tested on three major infrastructure projects in the UK. The platform will use real-time data, facilitating forward planning and collaborative decision making at team, project and portfolio level.

Clients, planners, site managers and engineers will be able to track real-time project performance and take action based on insights. The solution will track the status of each construction element (for instance all structural steel elements) from design, approval, manufacture and delivery, to site fitting/completion.

A feedback loop will enable predictive analytics such as early risk warnings, benchmarking across different portfolio projects and continuous 4D planning.



# The three corners of 4D

According to James Bowles, founder of 4D consultancy Freeform and chair of the 4D Construction Group, the three critical elements of 4D are technology, content and people.

## Technology

Since the early days of 4D modelling a decade ago, 4D technology has evolved significantly to become more accessible. Where previously it was the domain of a small number of highly skilled programmers, technologies such as 3D Repo are democratising 4D, bringing it into much wider use within a construction project.

## Content

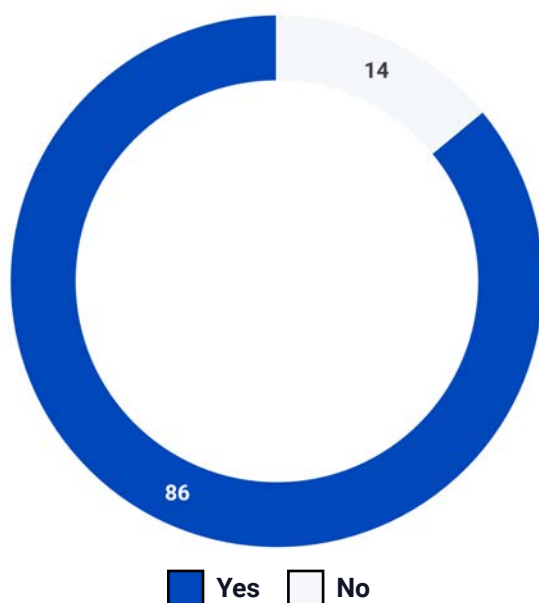
Alongside the improvement and accessibility that developments in technology bring, the volume and quality of information modelled have also improved and increased. This means not only can more detailed models be created, but they can be applied to a host of different applications.

## People

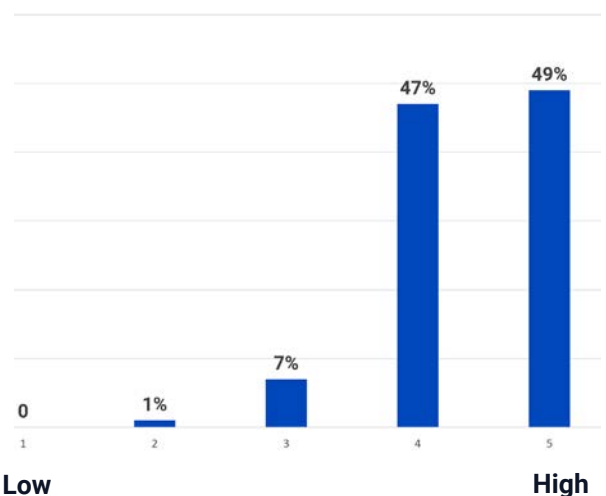
Perhaps the most important of these three critical elements of 4D is the increased willingness of people to use and interact with the 4D model. This means that the reach of 4D technology into the client and contractor organisations, into the project and amongst stakeholders has grown exponentially.

The end result of these critical changes in mindset, technology and information is that the opportunities for using 4D to improve efficiency and health and safety are growing significantly. This is borne out by the 4D Construction Group Survey<sup>5</sup> which found that respondents overwhelmingly had a positive view of 4D for saving time and cost on projects and improving safety.

**Will 4D be standard practice in 5 years?**



**How valuable is 4D?**



4D Construction Group survey – January 2020 – 119 respondents, not asked of 4D planners.

# How can 4D help to drive improvements and efficiencies?

As we have established, 4D should no longer be seen as the sole domain of the project planners. Instead, it can be used for a range of applications throughout the construction timeline.

- **4D for tenders**
- **4D for project planning**
- **4D for short term lookahead**
- **4D for as-built**
- **4D for health & safety**
- **4D and MMC**
- **4D and sustainability**





# 4D for Tenders

- Realistic visualisations of build-phase
- Competitive advantage for contractors
- Improved collaboration with project stakeholders

Currently, one of the most common applications of 4D technology is the production of realistic visualisations for use during the project tender stage.

As 3D modelling has become ubiquitous within all large-scale construction projects and BIM Level 2 is mandated for all government projects, stakeholders have become used to seeing high-quality 3D CGIs for every project.

Adding the time element to these 3D CGIs was the logical next step to show how the building would be

completed. This demonstrated that the contractor had carefully considered the programme and provided clear competitive advantage for those using 4D modelling at this stage.

Before the advent of 4D, contractors didn't always communicate how they were going to build. But with 4D modelling, it is easy for all stakeholders to visualise the project and many more people can be involved in the decision-making process.





# 4D for project planning

- Aids decision making for project planners
- Generative optioneering to identify best build solution
- Cost and time savings on site

With the help of 4D for construction project planning, users can see much more clearly where the dependencies lie and which phases of the build can run in tandem. This provides a much clearer, easier to understand overview than a detailed, multi-page Gantt chart with complex relationships.

However, there is a common misconception that before putting together a 4D project plan, the full 3D BIM model must be completed by the architects or structural engineers. But this is not the case. Instead, 4D planning can begin with a rough outline of a 3D model, using basic blocks and sticks. On a recent project we modelled just the cores, atriums and risers of a building, and demonstrated each floor as a block. This provided a

quick visual aid to help planning and decision making. Moreover, 4D has an additional advantage that it can be used for generative optioneering. Starting with the outline 3D model, it is straightforward to model different options for the build to quickly see which is the most efficient build process, which will be most cost effective, which will have the least impact on neighbouring buildings, which will involve less time on site for particular trades, plant or machinery etc.

4D opens up the project to a wider audience and enables more specialists to get involved. By bringing more people into the decision-making process earlier in the project, more appropriate decisions can be made earlier and costly mistakes can be avoided.

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# 4D for short-term lookahead

- More accurate short-term planning
- Clearer view on project dependencies
- Saving time and cost

In addition to longer-term planning, 4D can be highly valuable for short-term lookahead meetings. Short-term lookahead planning has proven itself to be highly valuable, but is at risk of extending the length of the project if the approach is too conservative.

While it can be helpful to ensure that one phase is completed before another starts, it can also result in significant time lost and therefore costly delays.

Research<sup>6</sup> by Hamzeh, F. R., Saab, I., Tommelein, I. D., and Ballard, G., which examined the role of simulation

in lookahead planning, concluded that by increasing the team's ability to properly anticipate tasks, avoiding the identification of new tasks at the last moment, and preparing tasks for execution can have a positive influence on reducing overall project duration.

With the help of 4D, the project team can have a much clearer view on project dependencies and can make much more accurate short-term plans, saving considerable time and cost.

# 4D for as-built

- Accurate record of the build process
- Time-stamped snapshot of your construction site
- Leverage data during disputes and claims

A 4D model is also useful for keeping a record of when and how something was built. With the help of onsite field tools such as mobile inspection apps and cloud hosted progress tools, tasks can be updated as they are completed and fed back into the 4D model.

This also provides a time-stamped snapshot of what happened on the construction site and when; which

contractors were on site; when deliveries were received; how products were installed and by whom.

This can be especially useful in situations post-build where there is a contractual dispute and claims are made. Moreover, it can make the claims process faster, simpler and less costly for all involved.



# 4D for health & safety

- Anticipate risks over time
- Reduce risk and improve health and safety on site
- Avoid near misses and improve social distancing
- Involve everyone to uncover more risks

One of the most important applications of 4D modelling is its ability to improve health and safety on construction sites. By visualising plans to show the movements of people, plant and machinery, it is much easier to spot where health and safety risks and problems might lie.

In particular, with the help of 4D planning, more time and space can be allocated for each set of people or trades to complete their work to avoid the situation of having a large number of trades onsite at the same time, causing unnecessary hazards and risks.

3D Repo's SafetiBase platform enables health and safety managers and project stakeholders to identify and manage risks within the 3D model.

Combining this with 4D technology enables teams to track the health and safety risks throughout a period of time. This is particularly important when large machinery is deployed, plant is moved, or people work at height.

With the collaborative nature of the 4D model, experts who were previously excluded from health and safety planning meetings can be involved, and risks across multiple projects can be analysed, helping to reduce health and safety instances in the future.

In addition, 3D Repo is now integrating with PLINX<sup>7</sup> which will enable social distancing and help to avoid near miss activity on the construction site. Operating via a series of tags, PLINX is a location-based technology that is designed to protect people, places and plant.



## Case Study: Harnessing 4D to improve health and safety

A number of 4D innovations in collaboration with HS2 via the UK's innovation agency, Innovate UK, are currently underway to improve construction site health and safety.

SafetiBase 4D, developed by Balfour Beatty Vinci JV (BBV) and 3D Repo, sees site workers enter a 'Mission Room'<sup>8</sup> which creates a four dimensional, 360° virtual version of a BBV construction site on HS2's Area North route. Here, workers can go on site and explore, discuss and agree the project's delivery sequence, identify safety issues and agree how to resolve them. They can tag hazards at a specific place and time in the virtual build sequence.

Building on the success of this project, 3D Repo is developing a customisable online health and safety training tool<sup>9</sup>, in collaboration with 4D consultancy, Freeform, and Balfour Beatty Vinci JV.

The new tool will feature live walkthroughs of site-specific 4D (construction sequencing) visualisations based on existing BIM models. This replaces generic training videos and will be delivered online via a cloud-based interface.

Health and safety aspects will be coordinated with the Health and Safety Executive (HSE) Discovering Safety Programme, to enhance opportunities for compliance and reusability throughout the industry and across other contractors.

# 4D and MMC

## ■ Help with factory scheduling

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## ■ Improve logistics for transport and installation

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## ■ Integrate with LEAN manufacturing methodologies

As the construction industry embraces MMC and increasingly adopts the use of standardised building components, modular building design, and design for manufacture and assembly (DfMA), the opportunities to embrace 4D modelling are significant.

4D modelling can be usefully deployed throughout the factory-based processes. From helping with planning schedules on the factory floor, to scheduling logistics to transport the modules and components to site, through to modelling the onsite assembly and associated plant such as tower cranes, 4D can become an integral part of every process.

When adopting MMC, there are many opportunities for the construction sector to learn from the manufacturing sector, for example by implementing LEAN manufacturing methodologies which help to improve efficiency and reduce waste.

It has been said that only when construction processes are more repeatable will we start to truly reap the benefits of MMC. The closer we can get to doing the same thing twice in construction the better, and 4D can help in this quest.

# 4D and sustainability

- Reduce carbon from manufacturing, transportation and assembly of buildings
- Reduce waste with better planning
- Benefit from just-in-time and LEAN methodologies

How we construct is just as important as what we construct and the materials we use. The UK has pledged to meet net zero by 2050 but the built environment is currently responsible for around 40%<sup>10</sup> of the UK's carbon emissions.

While switching to renewable energy sources and improving insulation will significantly help to reduce the operational carbon produced by buildings, as Architects Climate Action Network (ACAN) has stated in its recent 'Regulate Embodied Carbon' campaign, it is equally important to reduce the amount of embodied carbon<sup>11</sup> created in a building's construction.

According to the UK Green Building Council, embodied carbon is 'the total greenhouse gas emissions generated to produce a built asset'. This means taking into consideration the amount of carbon dioxide (CO<sub>2</sub>) emitted from extraction, processing and manufacturing, transportation and assembly of every building component and product used.

Here, 4D technologies can help to reduce the amount of embodied carbon produced through manufacturing, transportation and assembly of the building. By planning schedules more carefully and embracing just-in-time delivery, the right number of components can be delivered to site at the right time, helping to significantly reduce waste.

Moreover, by embracing LEAN methodologies for MMC, the industry can further improve efficiency and reduce waste.



According to the UK Green Building Council, the built environment is responsible for around 40% of the UK's carbon emissions.

# What's next for 4D?

After a gradual start, 4D is finally moving into the mainstream as costs and complexity of the software decrease, as more stakeholders are involved and as the many benefits and applications of the technology come to the fore. 4D is becoming embedded within construction planning departments as it is increasingly seen as business as usual rather than a specialist skillset.

From streamlining processes; through to saving time and costs; to improving health and safety; reducing waste; and improving sustainability, 4D can help the construction sector to meet many of the transformation challenges identified in the recent Construction Playbook<sup>12</sup>.

However, there is still some way to go in building awareness of the benefits and gaining funding for the projects.

In addition, there are currently no common industry standards or processes agreed for 4D projects. For 4D to become fully mainstream, there needs to be a consensus among stakeholders on what best practice in 4D looks like and how to replicate that across more projects. To help address this, the 4D Construction Group is currently designing an exchange of information requirements template to provide a common industry template to work with.



“While 86% of respondents to the 4D Construction Group survey<sup>13</sup> believe that 4D will be standard practice in 5 years’ time, 72% stated that the primary blocker to 4D adoption was the lack of awareness amongst leadership of the benefits.”



# Getting started on your 4D journey

The ability to be interactive with 4D will change the way that construction projects are run.

May 2021 figures from Glenigan<sup>14</sup> point to construction industry growth gathering momentum, with new contract awards up 50% on a year ago and importantly up 19% on pre-pandemic, 2019 figures, suggesting a sustained recovery in the sector. This growth in new projects heralds a great opportunity for contractors to embrace the value of 4D.

A broad range of stakeholders can benefit from having access to 4D technology. Using 3D Repo to bring the different elements together creates a collaborative platform for better communication. No matter what the source of the information, you will have the same streamlined experience in using 3D Repo.

**Contact 3D Repo to find out how 4D can benefit your construction project**

Email: [support@3drepo.com](mailto:support@3drepo.com)  
**3drepo.com**

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■ **Matthew Osment BSc**  
**Head of Digital Twins**

Matthew is the Head of Digital Twins at 3D Repo. Previously he has been consulting in the construction industry in various forms for the past 5 years, working predominantly with main contractors focusing on innovation and efficiency in planning and commercial activities, with a focus on BIM. Prior to that, Matthew was a product design engineer in the transportation and consumer goods space, learning about the power of parametric modelling, 3D as a communication tool and total quality management.



■ **James Bowles**  
**Founder of Freeform**

James is an engineer by background who began his career on site in main contracting. Passionate about using technology to improve construction projects, he founded Freeform in 2007 to help construction teams manage programme risk. An expert in 4D modelling, James provides clients with 4D planning advice and builds cutting edge 4D models.

James has worked on over 500 projects with a combined value of over £150 billion. He regularly speaks at conferences and seminars and runs the UK based 4D BIM expert user group.