People. Data. Technology.

UK EDITION

DIGITAL IN NUCLEAR: OUR VISION FOR 2035

POWERING CHANGE FOR A SUSTAINABLE FUTURE

AtkinsRéalis

CONTENTS

FOREWORD

THE FUTURE OF NUCLEAR

The UK government has boldly set out to 'lead the charge to global net zero'[1], positioning the UK as an international forerunner for greener energy. It is the first economy to have entered a legally binding target to reach net-zero emissions by 2050, while aiming to fully decarbonise the UK's energy system by 2035.

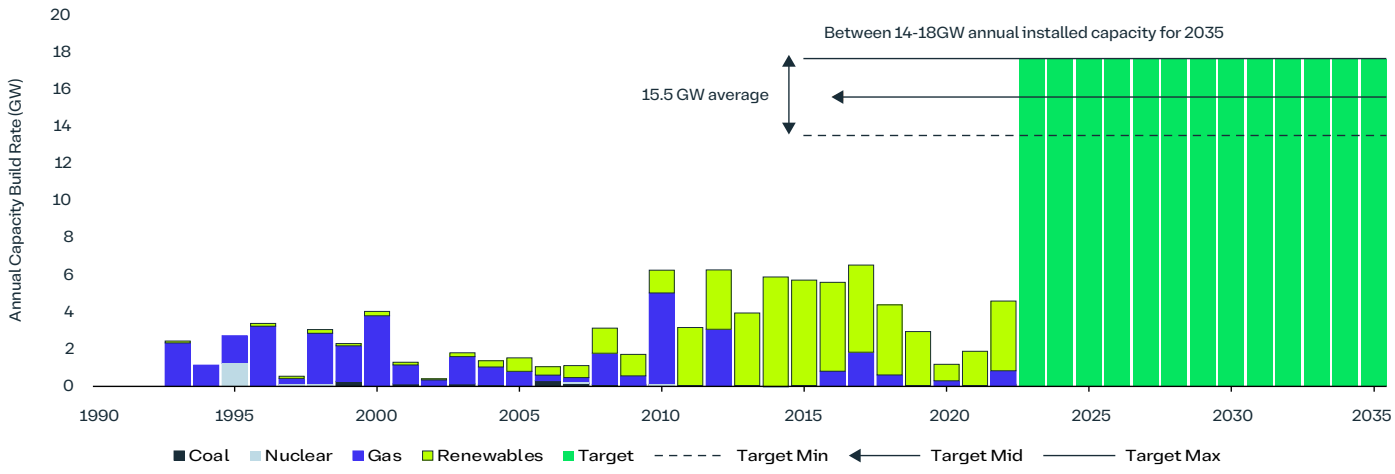
As evidenced in our most recent build rate analysis, published in January 2024, this will require an unprecedented increase in new electricity generation built each year. A five-fold increase, in fact. In the past five years, the annual build rate – how much new generation comes online each year – has averaged 3.2GW/ year. This means we will require up to 16GW of new generation to become operational each year, every year, from now until 2035 to meet the target[2]. This is the equivalent of building the UK's entire energy system twice over, in less than 13 years. These numbers paint a stark picture; time is not on our side.

Nuclear has been identified as a crucial player in achieving this goal, thanks to its position as the second-lowest emitter of CO_2 of any generating source, second only to onshore wind.

And with the constraints on wind power (evidenced in the record-breaking energy price increase in November 2021 due to a lack of wind), nuclear must play a key role in delivering a sustainable Net Zero. But nuclear isn't without its own blockers.

From a new build perspective, Hinkley Point C is currently predicted to come online before the end of the decade, while construction and commissioning of Sizewell C is expected in the mid-2030s.

> **"Many industries continue to operate in the same ways, with onsite uncertainty, bottlenecks and a lack of early warnings for potential issues, while hoping for better outcomes. Taking a digital approach creates a single-source of truth with a 360-degree view of the project and give clients peace of mind and reputational security that their projects can be delivered on time and on budget."**
>
> **Darren Grears**
> Director, Head of Digital, Nuclear and Power, EMEA, AtkinsRéalis



1 Net Zero Strategy: Build Back Greener
2 Countdown to 2035: can we meet net zero energy system targets? AtkinsRéalis, 2024

With the clock ticking, we must look at how nuclear can follow suit and make use of the increase in pace that digital can provide.

Meanwhile, the life of the UK's existing nuclear fleet is being extended beyond its original end of generation dates, to help ensure security of supply and tackle the recent dramatic spikes in wholesale gas prices, which are set to impact energy prices for years to come. Without these extensions, ten reactors would have already closed before the beginning of this decade. We must optimise this extension with digital transformation – from capturing data to automating maintenance checks – to increase efficiency.

Despite all this life extension, eight more nuclear reactors are due to go offline by the end of the decade[3], joining the 36 reactors already being overseen by the Nuclear Decommissioning Authority. Given the need for new power, the dismantling of these sites must be expedited, to free-up the land for new nuclear facilities. Here again, we need to make use of digital for its efficient delivery.

Unfortunately for us, we also have a second key challenge that needs tackling across the nuclear lifecycle: the skills gap. Simply put, we need more people. This unprecedented build rate will require a huge workforce, the number of people working at Hinkley Point C surpassed 22,000 people in 2021, with a cumulative 74,000 people expected to have contributed to the project by the end of the construction phase. The operations and maintenance stage of the nuclear lifecycle portrays a similar issue.

At the other end of the lifecycle, the UK's seven AGR stations will all be entering the decommissioning phase within the next decade; requiring a vast workforce to deliver this work. The problem is compounded when we look at the nuclear industry's workforce demographics: 39% of personnel are over the age of 50, while only 15% are under 30[4]. We're approaching a tipping point, where much of the workforce retires, taking with them their knowledge.

Once more, we must plug this gap in expertise with digital. We need to rapidly gather the information stored in the minds of the highly skilled older generations, and we must rely on digital tools to automate some of the tasks previously being performed by the shrinking workforce.

> **"Looking to the future, we cannot afford to continue on as we are. We are on a burning platform, and without the benefits of digital – efficiency, reduced costs, increased safety and sustainability – the future of the industry is uncertain."**
>
> **Sam Stephens**
> Director, Head of Digital, Nuclear, AtkinsRéalis

3 Nuclear Lifetime Management
4 Nuclear industry census reveals positive signs of growth alongside workforce challenges

DIGITAL SOLUTIONS

ENABLING TRANSFORMATION - DIGITAL SOLUTIONS

Digital has the potential to transform the nuclear industry

For many, this thought causes trepidation. What if I adopt a digital tool that's obsolete in five years' time? How do I know if I'm committing my time and budget to a solution that's actually going to realise benefits? Why do I have to bite the bullet, when I won't even be around to see the outcome? These are all valid questions.

Digital isn't simply a 'nice to have', it's imperative to:

- Ensure the security of the UK's future energy supply
- Keep sites operational from a workforce perspective

We may not get things right first time, but we need to explore the potential of digital tools and get workers accustomed to a digital way of working. Only then can we capitalise on the benefits of this fourth industrial revolution.

KEY DIGITAL SOLUTIONS ACROSS THE PROJECT LIFECYCLE

Looking ahead to 2035, we've identified five key digital solutions or approaches that we think will be vital to transform each stage of the project lifecycle, whether it is to support new build, generation or decommissioning. While each of these solutions are yet to fully mature, over the next decade we expect to see continued acceleration of their adoption in nuclear and supported by their use on other critical national infrastructure.

Throughout this report, we've shared how digital can transform the nuclear lifecycle, across four key measures:

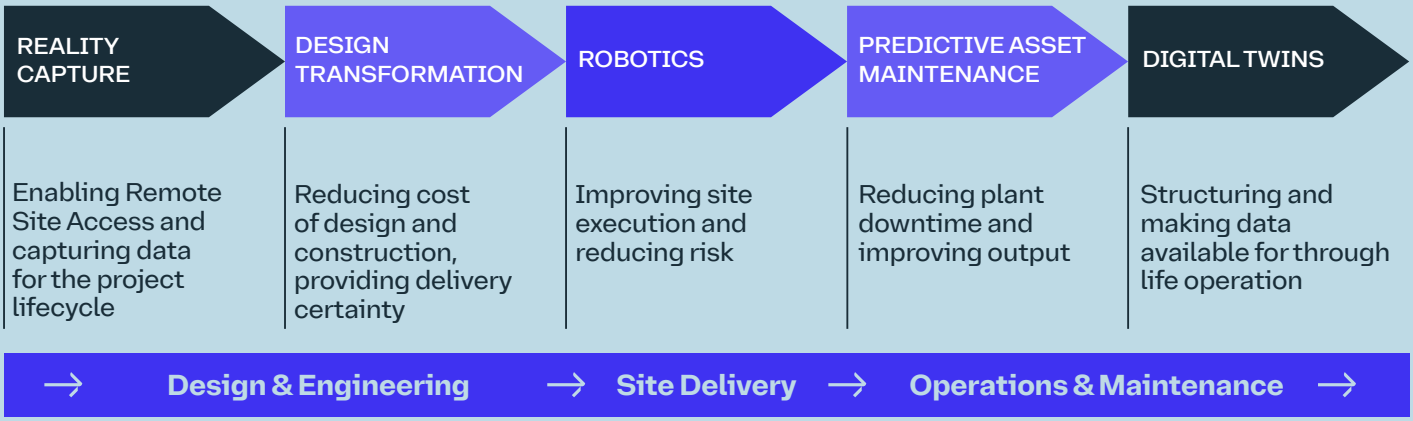
SUSTAINABILITY

EFFICIENCY

SAFETY

COST

PROJECT LIFECYCLE



DIGITAL SOLUTIONS

REALITY CAPTURE

Reality capture is an essential tool for improving design quality. It helps avoid historic misinformation and enables data to be collected against a model-based definition.

There are three main reality capture technologies used in nuclear operations today. We foresee continued adoption and integration with other solutions to positively disrupt the way we work.

LASER SCANNING

Used for spatial information, accurate dimensions, and location. It helps build a base of reliable data with which to start a project.

DRONE AND UAV SURVEYS

Used for master-planning across sites, these surveys provide high-quality imagery and help with assessments and regular surveys. They improve safety procedures by removing plant operators from high-risk zones.

360-DEGREE IMAGERY AND LIVESTREAMING

This is low-cost, off-the-shelf equipment such as GoPros, which also provides high-quality, 360-degree visual data and prevents repeat trips to sites.

Hands-free livestreaming from site also offers new ways of connecting remote workers to get new perspectives and contribute to rapid decision-making.

A key benefit to reality capture is that it limits the need for operators on site and enables virtual site access and monitoring.

From a Net Zero perspective, this leads to a carbon emission saving from reduced transportation. For the nuclear industry this also leads to a significant time saving; an efficiency much needed given the nuclear workforce is shrinking by 7.5% each year[5].

5 Nuclear Workforce Assessment 2021 – Nuclear Skills Strategy Group

DIGITAL SOLUTIONS

DESIGN TRANSFORMATION

Design transformation is about driving certainty in design and construction

Design and construction of major infrastructure projects, such as nuclear power plants, is incredibly complex but often some parts of the process are not optimised. For example, there may be a cost creep, subjective KPIs, ineffective prioritisation of tasks or worry about the reputational damage associated with delays in delivery.

Industry alignment around information management standards, such as ISO 19650, is a fundamental enabler to address these problems. From the outset, we need to ensure projects and assets adopt a fully collaborative and consistent digital approach through the project lifecycle with all information, documentation and data delivered digitally.

With this in place, major projects can not only be delivered faster, safer and cheaper, but also further opportunities to adopt new solutions can be opened up, such as design programme optimisation using artificial intelligence and advanced process simulation.

DESIGN PROGRAMME OPTIMISATION

AtkinsRéalis can call on a range of shedule analytics and optimisation solutions to pull together project data to a single source to provide a complete view of the project status. This data ecosystem gives the project team:

- Transparency on delivery status;
- Clarity on design risks in real time;
- Prediction of design outcomes and impact of design events on construction; and
- Optimisation, thanks to machine-led "what if" scenario analysis to aid decision making.

This approach is estimated to have a ~5-10% positive impact on design and construction costs. With inflation driving up the cost of all infrastructure projects in the UK, the potential for cost savings unlocked by design transformation is paramount to maintain the nuclear new build rate to power the UK's future.

ADVANCED PROCESS SIMULATION

Often referred to as a process digital twin, a transformative way of completing projects by integrating a process simulation model in the early stages of design, is already delivering benefits to process-driven industries.

The whole design is completed in a digitally integrated way to ensure that everything remains up to date, improving workflows between disciplines and ensuring that every activity adds value; reducing rework and significantly improving efficiency.

Savings of 30% could be realised through advanced modelling and 15% on the overall installed cost through optimising the design.

Design changes are also quickly evaluated through interconnected documentation and drawings with remote teams communicating virtually. The process simulation therefore becomes the backbone that enables control system verification, virtual commissioning and operator training, all helping to reduce start up time and overall project risk. Being virtual, handover of the final design to the operator is relatively simple, helping to manage future changes and making information readily available.

DIGITAL SOLUTIONS

ROBOTICS

Dull, dirty and dangerous tasks are being readily automated in manufacturing and logistics. Solutions are now sufficiently mature, reliable and cost effective to address challenges in the nuclear sector. The use of robots could reduce decommissioning timelines by a generation.

Decommissioning timelines are currently in the hundreds of years. Time constraints are often hazard-related. For example, there are places where a worker can only be working for as little as two hours a day due to radiation dose time and other hazards. By augmenting people with robots to carry out these tasks, time on site can be increased and so tasks can be completed faster. So, a 20% schedule saving over a 120 year programme could reduce overall timescales by a generation. By speeding up the decommissioning process, the UK would be able to then reuse the real estate for a new nuclear power plant sooner.

With more people retiring than joining the industry, we must look at where the human workforce can be bolstered by robots. The use of robots also helps tackle the decommissioning industry's workforce attrition, which currently stands at 7.5%.

Will we reach a point where workforce numbers include both humans and robots?

In a number of instances, robots are already being tested and used to complete hazardous and repetitive tasks within the nuclear industry.

Robotics on the Horizon

REMOTE MONITORING.

AtkinsRéalis uses mobile robotics for remote site surveys and data collection to enable new services, such as Virtual Site Access.

SORT AND SEGREGATE.

Leveraging AI and advanced control systems to optimise waste streams.

SIZE REDUCTION.

Laser cutting modules to reduce overall radioactive waste volumes.

GLOVEBOX OPERATIONS.

State-of-the-art vision, control and haptics systems to allow operators to carry out hazardous glovebox tasks remotely using robotic arms.

DIGITAL SOLUTIONS

PREDICTIVE ASSET MAINTENANCE

Maintenance costs are frequently driven upwards, thanks to aging assets and overreliance on dated reactive asset maintenance practices

Predictive maintenance enables the development of proactive asset management practices, ensuring that asset failures are predicted and prevented. This works through:

CREATING A DATA FOUNDATION

Enables integration, enrichment and aggregation of data in a way that can be used for machine learning modelling and for generating actionable insights.

MACHINE LEARNING

Using artificial intelligence (AI) to spot trends and predict asset failures, triggering proactive maintenance and asset failure prevention.

DIGITAL TWINS

Enables the simulation and evaluation of alternative maintenance and operational strategies, facilitating the identification of the most cost-effective operational policy for the plant.

BENEFITS

Outcomes of predictive asset maintenance include:

- Up to 30% reduction in maintenance costs; a key factor in ensuring the affordability of nuclear power.
- Up to 35% reduction in unplanned maintenance and downtime providing a security of energy supply.
- Up to 10% increase in Remaining Useful Life – critical given the plant life extension currently being undertaken in the UK.
- Potential for £10s of millions saved through asset failure prevention; another key factor for the overall cost of nuclear power to the operators and consumers.

DIGITAL SOLUTIONS

DIGITAL TWINS

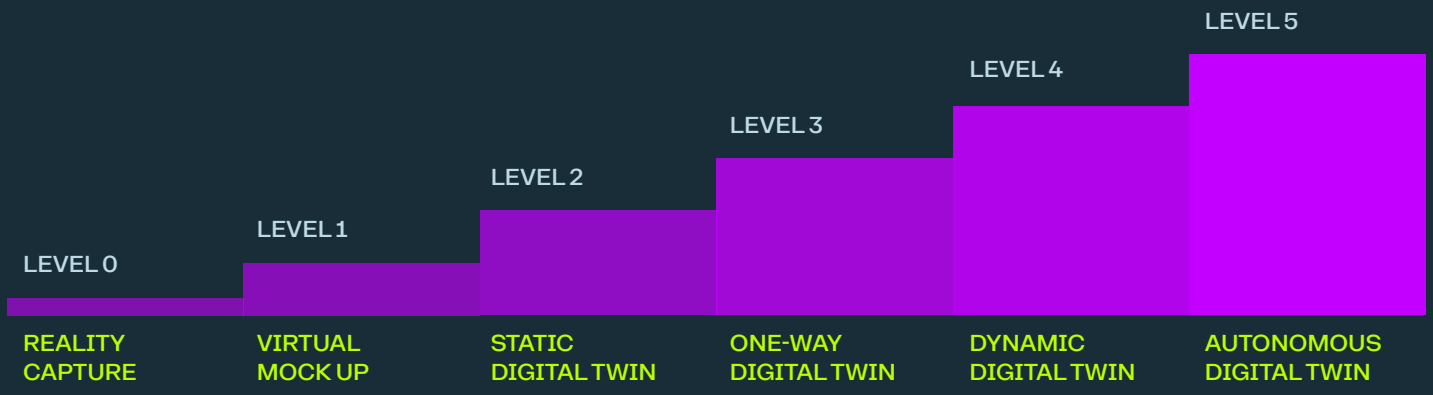
A digital twin brings together combinations of data that are accessible and clear

The digital twin maturity model developed between AtkinsRéalis and the Institute of Engineering and Technology[6] recognises digital twins of built assets can take many forms, breaking them into levels of maturity with increasing complexity and connectivity. By starting from the lower levels of maturity, investment can be progressively increased as value is realised from a digital twin strategy.

With late life operational sites and plants in decommissioning, our experience is that the stages up to Level 2 provide the most value.

This is where, often low-cost, existing technology can support digital data systems for future generations and make life easier for an existing workforce - as well as save money, time, and radiation dose.

Levels 3 and 4 are those more likely to be implemented at a new build stage or as part of plant life extension, as these are our future technologies and are unlikely to currently offer value for operating plants with a remaining lifespan less than a decade.



REALITY CAPTURE

Visual and spatial data, like 360-degree imagery, drone data, and point clouds.

BASIC MODELING

CAD information and 3D models of the site.

METADATA

Details of the site, such as materials and quantities, and 4D information such as timescales, activities and costs.

ONE-WAY INFORMATION

Real-time information from on-plant sensors, system monitoring or performance metrics.

TWO-WAY INFORMATION

Human-in-the-loop control of plant from the digital twin using robotics and actuators to fulfil tasks remotely based on live data input.

AUTONOMOUS

Integrations of machine learning and AI, enabling autonomous operations and maintenance.

6 Digital Twins for the Built Environment, The Institution of Engineering Technology, October 2019

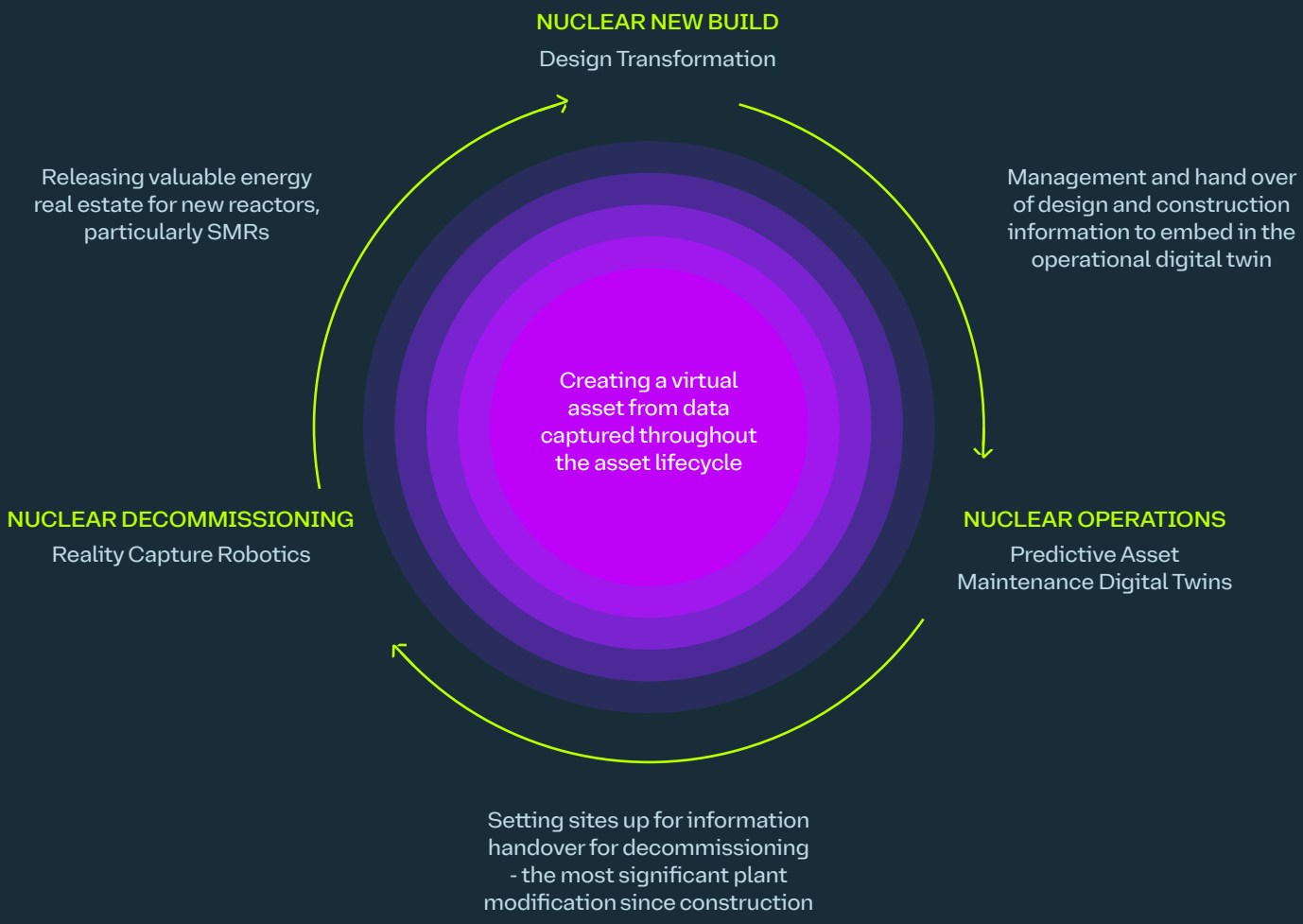
DIGITAL SOLUTIONS

EMBRACING DIGITAL AT EVERY STAGE

Digital has the potential to transform the nuclear industry

Digital has the potential to join up the three key stages of a nuclear asset's life, from construction, operation and through to decommissioning. By thinking strategically about how we collect, manage and exploit data at each of these stages, we can develop virtual assets that increase in value over a plant's lifetime.

While ultimately, we can see all five enabling digital solutions being used across these stages, we are seeing immediate application that can be used to inform future development.



DIGITAL IN NUCLEAR

NEW BUILD

Nuclear power plants are huge infrastructures with complex and unique industry challenges

Currently, digital tools are enabling a more efficient and robust build programme than we've ever seen before, saving time and money. For the new build stage of the project lifecycle, this has many benefits.

SECURITY OF SUPPLY

An unprecedented build rate is needed to achieve the decarbonisation of the UK's energy system by 2035. Our most recent analysis shows that 15.5GW of new generation capacity will need to come online every year for the next 11 years[7]. For the past year, nuclear has provided 15% of the National Grid's energy[8] - it's clear that nuclear is a reliable source of energy for the UK. For this to continue, we will need to build more. Nuclear can help us do this more efficiently, more sustainably and more cost effectively.

WORKFORCE CHALLENGES

If we're going to build all of these new sites, we're going to need people to build them. But with the skills gap only predicted to increase, we need to use digital to plug the gap and provide efficiencies wherever possible.

One of the most successful areas of digital adoption has been in the design and construction stages.

SUSTAINABILITY

Digital progress can reduce the carbon footprint within the engineering industry. The adoption of paperless technology means digital drawings can be viewed on a mobile device. Not only is this reducing printing, it's also facilitating more collaboration and accurate data retention. In practice, it means a designer can access complex instructions on site. This will increase the speed of decision making and enable remote expertise to be leveraged more efficiently.

FUTURE PROOFING WITH DIGITAL TWINS

Data captured during construction can add value throughout the nuclear lifecycle. One of the main challenges that engineers and operators face in the UK is the scattered and unstructured data from legacy plants. By recording and storing data from the start, we can help optimise the operations and decommissioning stages of a nuclear site.

> **"The new-build nuclear industry needs to embrace digital technology, and there's no other way to deliver a major infrastructure project. Every major engineering industry is embracing a digital future, and the supply chain is starting to demand it. If we don't adopt and adapt it, projects will only end up costing more."**
>
> **Tom Lambkin**
> Head of Nuclear New Build, Nuclear EMEA, AtkinsRéalis

7 Unprecedented Build Rate Required To Decarbonise Uk's Energy System By 2035
8 National Grid: Live Status

EFFICIENCY

DIGITAL REPLICATION

As much as data will be required in the distant future, it's also being put to good use today by enabling design replication.

At Hinkley Point C, the benefits of design replication are already being realised on delivery of Reactor 2 by capturing data and learning from delivery of Reactor 1. Key to realising the benefits of this 'learning by doing' is data storage and information management coupled with 3D and 4D modelling approaches.

Meanwhile, small modular reactors (SMRs) offer even further opportunities for design replication through simplification and standardisation by design to maximise the economy of series, as opposed to the economy of scale.

SAFETY

In our experience, the digital solutions outlined earlier can lead to inherent improvements in safety.

For livestreaming, the reduction of people on site will mean fewer people are exposed to the risks associated with nuclear sites, and indeed the risks involved in commuting.

Looking at replication, this knowledge-sharing will reduce unknown factors, therefore increasing safety.

COST

Cost savings are imperative for the business case for new nuclear. Digital can facilitate these savings across a number of different technologies.

For example, at Hinkley Point C, the aim is for digital replication to be transferred to Sizewell C and result in cost savings as great as 20%.

This digital replication can also be realised throughout a single project thanks to advanced process simulation. These digital twins use process simulation to test different options, so designers can choose the safest, most efficient and most cost-effective option at every turn.

MAIN CHALLENGES

- High-risk sites with complex challenges.
- Organising high volumes of data and analytics.
- Cost and time constraints due to long construction times and high initial investment.

DIGITAL SOLUTIONS

- 3D digital design.
- Design programme optimisation using data science.
- Remote technology, including video streaming, drones, and robotics.
- Digital replication, harnessing information management.
- Process simulation and digital twins.

REALISING THE POTENTIAL

NUCLEAR NEW BUILD

New build nuclear plants need to be part of our energy future

The potential for digital to transform this industry is huge. In fact, new build is where digital technology can be implemented from the ground up. By adopting digital at this stage of the project, the most benefits can be realised throughout the plant's lifecycle.

But that doesn't mean that the benefits are reserved for the latter stages of the lifecycle.

Looking at the offsite construction of SMRs, cost savings of 4-10% could be achieved thanks to Building Information Modelling (BIM)[9]. For large nuclear sites, the savings could be as high as 20% if digital replication is used. Largely, these savings come from an increase in efficiency, meaning sites also get built faster.

Through the capture, reuse, codification and analysis of data, as much as 80% of time can be taken out of the traditional design process[10].

When it comes to the business case for new nuclear, the savings and benefits of adopting digital solutions will help underpin the central role nuclear has to play in helping power the UK for generations to come, as part of the low-carbon energy supply.

These efficiencies translate through to the workforce, too. If there's less design work required of personnel, the strain on the workforce will decrease. And with the aforementioned analysis being done digitally, the design team doesn't even need to be onsite, opening up the work to a global talent pool.

9 Off-Site Modular Construction And Design In Nuclear Power: A Systematic Literature Review
10 Application Of Moka Methodology In Generative Model Creation Using CATIA

DIGITAL IN NUCLEAR

OPERATIONS

When it comes to energy supply, the existing fleet of nuclear assets in the UK has been kept online much longer than originally anticipated

This energy is paramount to our security of supply, and means we must get the absolute maximum value that we can from these assets.

From a workforce perspective, this means a lot more people are working in operations and life extension. Each site is competing for skilled workers. The role of digital as an enabler is vital to fill the gap.

Already, we have delivered modifications to sites digitally, using innovative solutions to keep the lights on. These benefits are even further amplified when we think of the impact over the remaining operational life, and even how they can inform the operational strategies for future new build assets.

The tools that can help us deliver this are:

- **Digital twins** creating a single source of truth, where all relevant information is accessible to users;
- **Predictive asset maintenance** streamlining operations by automating where possible; and
- **Robots** taking on tasks that can be automated, freeing up the human workforce.

Meanwhile, the grid is becoming increasingly digital, and sites need to be ready. Even more digital adoption will come down the pipeline, and if we don't embrace it now, we risk being left behind and unable to cash in on the future benefits.

Yes, digital technology has historically been difficult to implement. As William Magwood, Director General of the OECD Nuclear Energy Agency highlighted, it is "a lot more difficult than it may sound"[11].

One key factor is cost. Legacy plants may have been built in accordance with state-of-the-art specifications at the time, but digitalisation of an existing asset can seem expensive. But we can't afford to delay. And the benefits of optimising processes are worth it.

DESIGNING OUT DELAYS

Delays in operational projects are not uncommon due to the time it takes to unearth relevant data.

Think old documents left in a box that no-one has looked at for 20 years. Or having to search through millions of archived emails for a crucial measurement.

There is a lot of information, and scouring this eats into project time, and therefore into cost and efficiency. It's one of the biggest challenges the industry faces.

This is where reality capture technology, predictive asset management and digital twins can transform nuclear operations.

11 Nuclear Industry Must Embrace Digital Age Says NEA's Magwood, 2021

There has been a recent upsurge in digital adoption within nuclear operations. Digital technology is helping to solve historic issues, such as inaccessible and poorly stored data. It's improving the safety and speed of operator tasks, and ultimately reducing costs along the way.

SAFETY

Safety is at the heart of all work on a nuclear site. Thanks to digital solutions, we have an opportunity to further enhance this safety by minimising exposure to harm. Thanks to remote access, we can reduce the number of individuals that need to be on site.

This can be enhanced by robotics, with the likes of Boston Dynamics' Spot quadrupedal robot able to perform a scheduled data sweep of a site, providing information that can then automatically upload to digital twin platforms, like AtkinsRéalis' reality capture data management solution, CIRRUSinsite[12].

Digital advancements in condition-based monitoring are also being explored today, with reality capture technology and robotics. These will see the landscape of plant monitoring become safer and more remote. With digital aids to send to remote sites, we'll be able to capture conditions in real-time, spot any early signs of degradation and fix them faster. Operators will be able to work increasingly remotely, and failures will be minimised by the proactive response to real-time information.

EFFICIENCY

Predictive asset maintenance has the potential to drastically increase the efficiency of nuclear operations.

This could include anomaly detection, which tracks performance against a predicted reference to identify anomalies.

Another method is machine learning, which would see the platform observe historical failures, leading to the prediction of future failures based on asset behaviour. Experience has shown in other industries that prediction of asset failures can save up to 35% of unplanned downtime and maintenance.

Relying on this digital tool also increases the productivity of the workforce, with employees free to concentrate on other tasks that can't be automated.

12 Cirrusinsite Digital Twin Survey Platform

SUSTAINABILITY

Training new employees takes time and reduces the efficiency of long term workers. And with a workforce that's generally regarded as aging, across civil and defence, the nuclear industry needs to find a way to pass along knowledge from its departing staff to new starters. One way of undertaking this is through immersive training, making use of virtual and augmented reality, which can be stored in a central repository and accessed by all relevant staff. This ensures the passage of critical information, while also reducing time spent by experts on training up each cohort of new starters.

COST

As a nuclear asset approaches the end of its operations, you may think that the time for investing in digital enhancements has passed.

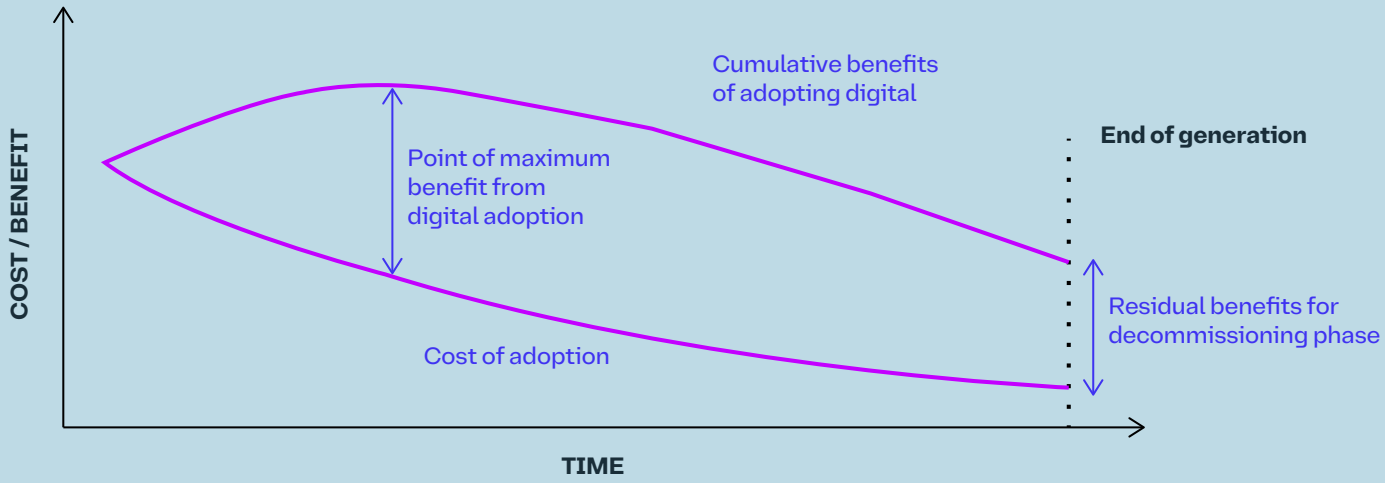
But the sooner a site goes digital, the earlier it can reap the benefits. By setting up digital processes in the operations stage, all of the information is gathered in the right place to aid decommissioning. If a digital approach was taken during the new build stage then this is even easier, as processes are set up and the base information just needs adding to.

MAIN CHALLENGES

- Fractured and unstructured data.
- Dose time and high-risk jobs for operators.
- Existing nuclear operations are soon to be decommissioned.

DIGITAL SOLUTIONS

- Reality capture technology
- Digital data storage
- Level 0-2 digital twins
- Immersive visualisation for design review, training and site support



REALISING THE POTENTIAL

NUCLEAR OPERATIONS

The operations and maintenance stage accounts for more than 60% of the total cost of nuclear power plants[13]. Surely there is potential for digital to make an impact?

The nine nuclear power reactors still generating in the UK should have operational lives of at least 40 years[14]. With these assets still generating power, we have an opportunity to test new digital solutions that can help inform the operations of the new build fleet as it comes online. New solutions are maturing in other industries and now is the time to adopt and test them in nuclear.

Delaying the decision to invest in digital solutions will only push the benefits further down the line.

Even if we are not optimising digital solutions, we need to capitalise on the benefits that are available to us. Decisions need to be made now to realise the potential of digital and ensure we have the workforce and security of supply required to keep powering the UK.

13 Nuclear Power Economics - Nuclear Energy Costs World Nuclear Association
14 PRIS Country Details (IAEA.Org)

DIGITAL IN NUCLEAR

DECOMMISSIONING

The case for investing in digital during the decommissioning stage is clear

But some may question the benefit of investing so late in the lifecycle, asking why invest in expensive technology, when the plant is at the end of its lifecycle? But there are plenty of benefits to be achieved.

Firstly, we have a large fleet of existing assets that will need to be decommissioned in the future. By 2030, power generation is expected to have ended at all seven of EDF's advanced gas reactor (AGR) nuclear power stations, and each site will be at varying stages of defuelling and decommissioning. Managing this task will place increasing demands on an already stretched workforce. To deliver on commitments, they must be supported by digital solutions to become as efficient as possible.

Secondly, this huge decrease in energy generation will put pressure on the UK's power system. Using digital as an enabler, we have an opportunity to accelerate decommissioning of these sites, to reuse the valuable energy real estate for new nuclear plants and SMRs.

COST

One of the main challenges that decommissioning sites face every day is sourcing reliable data. Modifications made during operation aren't documented in a way that facilitates dismantling and demolition.

Challenges arise during decommissioning projects when unexpected anomalies crop up. Having as much information as possible before starting on decommissioning can make all the difference to time, cost, and safety.

Yet often the information stored is unreliable. Historic modifications and alterations may not have been captured correctly. It could be that the plans an engineer is referring to do not match the reality of the plant as it stands today. This data loss impacts the timescales for projects. It impacts the workforce and their dose uptake. It impacts cost.

This is where the real value of data capture technology comes in. A variety of technologies are currently being implemented to provide an accurate picture of a nuclear plant as it exists now.

We can record and map the current areas, current conditions and the state of the building and site. It's not new or expensive technology — sometimes a simple £500 Go-Pro can provide an accurate 360-degree view without putting multiple workers in high-risk areas.

Not only is it cost-effective, but it's scalable technology. Low-cost data capture can be used to create 3D models of the entire site - the kind that can be mapped onto a digital twin.

SUSTAINABILITY

GATEKEEPERS OF KNOWLEDGE

Information about a legacy plant is not only stored in records but also in the minds of those who have worked on site — some for their entire career.

Nuclear power is an industry with a long timeline. For example, a decommissioning programme can be scheduled to run for 120 years. Add to that the complex and consistent challenges it faces every day, and you begin to understand why expertise stays within the industry for generations.

Decommissioning, in particular, holds unique challenges for each site. While new-build plants are efficiently designed to be replicated, our older sites have been built and adapted by many people over time. So, this is an industry where one person's knowledge can make all the difference. These are the people who have lived and breathed the nuclear industry for the last 50 years — and one person has a lifetime's worth of knowledge. They are experts and they are one of the most valuable sources of accurate data.

Currently, every retirement means a new loss of information, expertise, and skill. The loss of these 'gatekeepers of knowledge' has been accelerated over the recent pandemic, as the older generation considers their retirement. Already, 39% of nuclear personnel are over the age of 50. And the number of subject matter experts (personnel with authority in a specific work area, developed through 10 or more years' experience of the subject, likely to hold the highest technical knowledge for that subject in the organisation) has dropped by 7.5% in the last two years. So, it's become imperative to capture their knowledge now in order to support plant deconstruction now and into the future.

CURATING AND FACILITATING KNOWLEDGE TRANSFER

As with plant data capture, it's not complex or expensive technology that is being implemented. An interview with an expert can provide a reliable 'how-to' video that could save a person trawling through an old, out-of-date 30-page document. Video walk-throughs, for example, are simple to create yet invaluable. A digital film of the plant area can be captured using a drone or a Go-Pro. The footage is then shared on-screen during a recorded interview with the expert.

EFFICIENCY

Simple data capture at this level can save time and money, and ultimately create a faster and more rewarding project development for the engineer involved.

Staying up to date with technology will be one of the biggest drivers in retaining a new and existing engineering workforce, as the older generation retires. Digital brings opportunities to bridge the gap between old knowledge and new learning.

FUTURE GENERATIONS

Decommissioning of Sellafield began in 1988, with a 120-year plan for its programme of work. If you consider the workforce and skillset involved in that project, that is an opportunity for three generations to forge their engineering careers in a nuclear setting.

Shown in this light, it's apparent how important it is to ensure that information and data are easily accessible to the next generation. We have a responsibility now to make sure that in 30 years' time someone isn't still asking the question: "What's behind that door?'.

Changing the way we do things can be as straightforward as saying to someone: "don't use a tape measure," because tomorrow's tape measure is a laser scan.

SAFETY

REDUCING THE RISK FACTOR

Nuclear is a very safety conscious industry, so anything that reduces the risk factor will also reduce time and costs. As digital adoption has proved at Sellafield.

On a design and construction programme scheduled for 12-weeks, there were two time constraints that could hinder the construction engineers:

1. Dose levels meant that employees were on short shift work and only so much construction could be physically completed during the day.
2. Patchy and inaccurate information meant that extra time had to be factored in to manage the unexpected.

DOING THINGS DIFFERENTLY

Digital technology is now used throughout the design phases. For example, 3D models, laser scans and the latest modelling packages were all used to design new equipment to be installed in a high hazard area. The result was a schedule that was completed in eight weeks rather than the expected 12 weeks – a 30% time-saving.

The team could see and problem-solve many of the challenges before work was even underway. When you can see the bigger picture in more accurate detail, certainty is increased, and programme length is decreased.

"That's not simply a 30% time saving, it's also a cost-saving and a 30% dose- time reduction for the workforce.

Darren Grears
Director, Head of Digital,
Nuclear & Power EMEA, AtkinsRéalis

MAIN CHALLENGES

- Inaccurate and inaccessible data.
- Retiring generation with critical knowledge.
- Time constraints due to dose time and safety.
- Time and safety constraints lead to increased overall costs.

DIGITAL SOLUTIONS

- Reality capture.
- Digital interviews and videos.
- Virtual site access and monitoring.
- Robotics.
- Level 0-2 digital twins for decommissioning.

REALISING THE POTENTIAL

NUCLEAR DECOMMISSIONING

Already data capture technology means we can improve the safety of the workforce and reduce dose time

Reality capture means one trip and one operator is all that's required. The data is then accessible to a whole team without having multiple trips to the site and risking forgetting anything.

The next step is enabling more work to be completed by a remote workforce or autonomously. The future is all about removing people from high-risk areas. A glove box operator, for example, who no longer needs to put their own hands in a glovebox. They have a machine, which they operate to carry out hazardous sorting. This would eventually move to remote operation, where the workforce would control the robotics from afar — meaning a complete reduction in dose time. Remotely operated glove boxes are on track for implementation within the next few years.

CARBON REDUCTION

Digital technology can also provide us with a more sustainable method of operating to support Net Zero targets. Nuclear legacy sites are in remote places; sites that are difficult to access and away from your usual infrastructure. Even travel to a site multiple times and with large project teams can create a large carbon footprint. With remote access technology and remote data capture such as AtkinsRéalis Virtual Site Access suite of digital services, the nuclear industry has the opportunity to drastically reduce its carbon emissions. Currently, an employee will visit a site with a laser scanner or a drone to make assessments, take measurements and gather live data. However, in the next few years, the majority of this could be completely remote - utilising quadrupedal robots, UAVs and drones operated from a remote mission control centre.

MISSING A TRICK

Decommissioning a reactor can be a half-billion-pound investment. It is the most significant plant modification that a site will see since its construction. Any other major infrastructure project of this scale would leverage all the latest tools... so why should the nuclear industry be any different?

THE GLOBAL OPPORTUNITY

Many of the UK nuclear sites have entered decommissioning before their counterparts in other countries around the world. We have the knowledge and the expertise to take to the global stage. It's a growth market with programmes stretching into the decades.

Adopting digital technology and engaging the next generation of bright, new engineers who can drive the changes we see on the horizon, will enable us to provide our expertise across the globe, with a reduced need to relocate or travel. It will also be crucial in retaining our workforce and staying at the forefront of decommissioning technology and nuclear engineering.


AtkinsRéalis

EMBRACING THE DIGITAL CULTURE

WHAT'S STANDING IN THE WAY OF MAKING THIS HAPPEN?

There are a number of blockers standing in the way of the nuclear industry's digital transformation

> "We really need to go beyond just the research and bring the whole sector into the 21st Century."
>
> **William Magwood**
> Director General of The OECD Nuclear Energy Agency

1. ATTITUDES TOWARDS ADOPTING NEW TECHNOLOGY

Bringing digital technologies to nuclear operations can be a sensitive area. Public opinion on robotics and AI is a complicated arena. While some see the benefits of AI in reducing human risk, there is a prevalent mindset against robotics in society. A representative survey across the UK population on their perceptions of AI found that 'levels of concern were higher than levels of excitement' with participants fearful of a dystopian future scenario[15]. For those working in the nuclear industry for most of their life, robots and AI are being approached with caution. Some believe it will make their lives more difficult, and some fear it will replace them altogether.

This is a common fear across sectors that are beginning to introduce AI. There is a widely held perception, which is not limited to any particular age range, that robots will inevitably take the current workforce's jobs. But this isn't about replacing people with robots, because there aren't people to replace.

With an aging workforce and an attrition rate of 7.5%, the nuclear industry will reach a point in the near future where there aren't enough people to complete tasks, and this gap needs to be filled somehow.

If embracing digital is necessary to secure the future of the industry, why not do so wholeheartedly?

> **The greatest joy from a digital team perspective is seeing that a technology they have been resisting has just changed their life for the better. Suddenly their whole attitude changes: they are excited and re-engaged. More and more things become possible, and more doors open."**
>
> **George Wormald-Kelly**
> Digital Implementation Lead, AtkinsRéalis

2. CYBER SECURITY - PERCEIVED WEAKNESS

When previously surveyed, critical national infrastructure operators revealed they have low confidence in cyber security[16]. Yet the biggest risk to cyber security is people. 99% of cyber attacks use social engineering techniques, such as phishing, to trick users into installing malware[17]. So, it's not the digital technologies that are risky, it's the people operating them. Not only is storing information digitally a more sustainable solution compared to printing reams of data, it increases organisation of data – and therefore efficiency. And with training for employees on the best way to store and secure information, it can be a safe solution for the storage of critical information.

15 'Scary Robots': Examining Public Responses To AI - AtkinsRéalis
16 Staff And Supply Chains Are Great Est Cyber Security Vulnerabilities For Critical National Infrastructure And Defence Organisations – AtkinsRéalis
17 What Is Social Engineering? | Techniques & Prevention (Itgovernance.co.uk)

3. BUSINESS MODELS - STACKING THE VALUE

Adoption of digital tools requires an upfront cost, which could lead to the perception that digital is expensive. But this doesn't mirror the truth. Commercial models often don't recognise the benefits of digital; they need to be viewed through a longer-term lens, as the benefits to digital can be reaped for a long time. For example, if a digital twin strategy is developed and implemented during the design phase of a nuclear power plant, the data can be harnessed throughout the operational and decommissioning phases. Likewise, if you're going to invest in a robotic arm to sort and segregate radioactive items, surely, it's more cost effective to purchase it sooner rather than later, so you're getting the most use for the cost? It's more advantageous to adopt digital as soon as possible to get the most reward.

Also, with an unprecedented build rate required to keep the lights on and a looming skills gap, can we afford not to embrace digital?

4. URGENCY - LEARNING FROM CHANGE POWERED BY THE PANDEMIC

In March 2020, the Covid-19 pandemic ground much of the economy to a halt as lockdown rules were enforced. Yet, like other power plants, operating nuclear sites could not be furloughed, continuing operations to power a nation working from home.

Instead, the pandemic instigated the fast adoption of digital technologies within the nuclear industry. The critical need to keep personnel on site to a minimum meant that Data Capture Technology became invaluable. Technology that had been at incubation level, was accelerated into service. For example, instead of a team site visit, one person with a live streaming service or an augmented reality headset could relay real-time information to a team of 20 or 30 people.

"When the pandemic hit, it was as though the world came to a halt, however, the critical work at Sellafield had to carry on. Changes in the attitudes and acceptance towards cutting-edge technologies, such as Augmented Reality (AR) livestreaming, enabled this vital work to take place from afar; minimising the number of people that needed to be on site, reducing carbon emissions from travel, and saving tax-payer money. Through the difficult challenge of balancing information security and business benefits, advanced image capture technologies have slowly become business as usual at Sellafield. Looking to the future, I envisage these technologies playing an increasingly important part in our operational and digital strategy."

Katherine McKinnel
Information Security Advisor
at Nuclear Waste Services

Looking forward, the industry needs to take learning from the rapid progress achieved during 2020 and 2021 due to the sense of urgency initiated by the pandemic. Where government investment is made to support or deliver nuclear projects, providing incentives to prioritise development of digital maturity can push the industry forwards, increase efficiency on sites and make finances go further.

CONCLUSION

Throughout this report, we have sought to show how digital tools have the potential to transform nuclear

But more importantly, we have highlighted how digital can tackle the two main issues that threaten the nuclear industry at present — security of supply and the skills gap. When it comes to the UK's energy supply, the UK must build 150 – 200GW of new electricity generation assets by 2035 to replace ageing power plants and ensure enough capacity is built to meet the expected peak demand.

Add to that the dilemma that the nuclear industry is losing more people – mostly to retirement – than it is gaining each year, at an attrition rate of 7.5%. With over a third (35.2%) of the workforce across civil and defence nuclear over the age of 50, the largest portion of the industry's personnel will likely be moving into retirement in the next 15 years[18], further exacerbating the skills gap the industry is already facing. These issues are unavoidable. We need digital to keep things moving; we're already behind schedule and without it we have little chance of catching up. The additional benefits of embracing digital are also hard to ignore. These tools can plug the gap across a number of factors:

SAFETY

Distancing humans from potential harm.

SUSTAINABILITY

Optimising the end-to-end delivery process. Cutting carbon emissions from travel. Paperless design. Introducing an engaged, remote workforce to the global market.

EFFICIENCIES

Driving efficiencies with tools that can work longer hours than the human workforce. Making information easier and faster to access.

COST

Savings made through efficiencies such as reducing project time and removing commuting costs.

Surely the path to a digitally-enabled nuclear lifecycle is a clear one. And yet there are a number of blockers standing in our way. If it were as simple as studying the benefits and seizing the opportunity, it would have already been done. Instead, we are faced with the biggest issue: the perceived risks.

Lack of trust in robotics, fear of security risks, unclear financial benefits brought about by commercial models that aren't set up for capturing the long-term value, all stand in the way of getting the ball rolling.

A survey into how prepared the UK's built environment industry is to deliver a golden digital thread of information demonstrates that this is a problem across not just nuclear. 75% of respondents said that the industry's biggest blocker to this digital golden thread is industry culture. Meanwhile, technology was of the least concern[19].

Exploring further, we can look at why people may feel this way. According to the same survey, a mere 21% of respondents believe their organisation will seek help to understand and deliver the digital golden thread. In a different question, an overwhelming 79% said it wasn't clear where to even go for support.

Looking at these results, it becomes apparent that organisations such as our own have a huge role to play in taking others on the digital journey, demonstrating what a digitally enabled nuclear lifecycle would even look like. And importantly, how we get from the current day to this future landscape.

Adoption will need to be incremental, with tools adopted and embedded into the process like building blocks for the next level of digital to be realised. Here's where we suggest starting...

18 Nuclear Workforce Assessment 2021
19 The Golden Thread

	NOW →	2025 →	2030 →	2035 →
NUCLEAR NEW BUILD	**PROVING ON CURRENT BUILD PROJECTS** ▪ Paperless delivery on site ▪ Site monitoring with drones ▪ Transforming design delivery ▪ Adopting ISO 19650	**DIGITAL TWIN ENABLEMENT** ▪ IM standard for new build projects, cookie cutter CDE ▪ Complete construction monitoring ▪ Optimising delivery with AI	**DIGITAL BRINGING STANDARDISATION AND REPLICATION** ▪ Proving replication on site ▪ Construction experience data to improve 'nth of a kind' delivery	**DIGITAL NEXT GENERATION** ▪ Digital Power Plant ▪ Designing in predictive maintenance and AI into new reactors (e.g. STEP)
NUCLEAR OPERATIONS	**DEMONSTRATORS ON EXISTING ASSETS** ▪ Developing Process Digital Twins of key systems ▪ Using machine vision to identify plant issues	**BENEFITS REALISATION ON GENERATING FLEET** ▪ Deploying sensor networks and IOT platforms ▪ Optimising systems with AI ▪ Surfacing data to the Virtual Energy System	**TRANSITION TO THE NEW FLEET** ▪ Digital Twin ▪ Bringing AI into the safety case ▪ Integration with the Virtual Energy System ▪ Paperless modification	**CONNECTED POWER PLANTS** ▪ Remote monitoring of supporting systems ▪ Refinement and optimisation of predictive maintenance algorithms
NUCLEAR DECOMMISSIONG	**DIGITALISATION PROCESS FOR DECOM SITES** ▪ Knowledge capture from retiring workforce ▪ Robotic solution development ▪ Virtual site access and monitoring ▪ Paperless asset condition reporting ▪ Security patrol demonstration	**FIRST OF A KIND CONTINUOUS REACTOR DISMANTLING (CRD)** ▪ Information handover standard for decom ▪ Robotics rollout, automated sorting & segregation of waste ▪ Remote operations in gloveboxes and hazardous areas ▪ Autonomous inspection	**ENABLING A ROLLING PROGRAMME OF DECOMMISSIONING** ▪ Data capture from CRD - data driven decisions for future sites ▪ Convergence of data streams ▪ Schedule optimisation	**DATA DRIVEN DECOMMISSIONING** ▪ Every facility has a digital twin ▪ Robot augmented workforce ▪ Reliable, repeatable decommissioning programmes

People. Data. Technology.

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