Gemini Papers:
Summary Paper

cdbb

Forewords

Dame Wendy Hall DBE FRS FREng MAE FIET

Regius Professor of Computer Science and Executive Director of the Web Science Institute at the University of Southampton

Let's be clear. An ecosystem of connected digital twins is a moonshot. It is going to be incredibly hard to achieve properly without vision, ambition and the right information architecture. If we get this right the change could be as transformative as was the World Wide Web itself.

What excites me about these papers is seeing a blueprint for how we can achieve this moonshot. As a computer scientist I am particularly interested in the technical interoperability and how we build a digital chain. Equally, of course, is that it must also work for people, it must be socio-technical. We must learn from each other how best to interoperate for the good of society.

It's vital that we work in a coordinated and collaborative way to establish standards and appropriate governance structures. If we work in silos, or behind closed doors, there will be no shared common vocabulary for exchanging data, ideas and models.

It is hugely important for the country that we get behind this vision. CDBB has mobilised government, academia and industry to advance the vision. We need continued leadership and investment in the digital built environment, and people who passionately want to make it work.

Those who take the blueprint forward should be mindful that this socio-technical project is about much more than data, AI, synthetic environments, connected digital twins on a national scale, living labs and smart machines. It is about ensuring better outcomes for people who use and depend upon the complex, interconnected system of infrastructure. We must not lose sight of our fundamental purpose – data for the public good. We must not lose connection with people.

Before us stands the opportunity to build on the foundational work of CDBB; to grow as an economy; and to build in resilience as we recover from the pandemic and face climate change. We have the blueprint. Let's use it.

Gemini Papers: Summary Paper

Professor Andy Neely OBE FREng

Founding Director of the Centre for Digital Built Britain

Without ambition we cannot innovate. Since a National Digital Twin was mooted in the National Infrastructure Commission's Data for the Public Good report, government, academia, and industry have come together to take bold strides towards making it a reality.

Without a path we can lose our way. Knowing what our shared ambition is, why it is important and how to make it happen are fundamental to achieving our goals. As CDBB steps back from its role as a coordinator and convenor, we are sharing all that we have learned so far so that the sector's journey continues at pace.

To those who take these lessons forward, make sure to bring people along with you. CDBB always had an open door, and our success was shaped by that broad collaboration.

The conditions for success have never been better: there is strong policy support, and an engaged sector and clients asking for digital twins. These papers set out a clear vision and compelling argument for how ecosystems of connected digital twins can help nations and nature thrive when developed with public good at their core.

My heartfelt thanks and congratulations to everyone who has shared the journey with us on the National Digital Twin programme and all its associated parts and partners. Thank you, too, to everyone who has so generously shared their thoughts, insights, and learnings in these, the Gemini Papers. They remain an embodiment of the spirit of collaboration that has guided us to this point.

Mark Enzer OBE FREng

Head of the National Digital Twin Programme

Ecosystems of connected digital twins promise significant benefits. They are key enablers of an equitable future that we all desire. By helping us to understand systems better and to intervene more effectively, connected digital twins could unlock social, environmental and economic benefits on an unprecedented scale. They can help us address the greatest systemic challengesof our age, such as achieving net zero, delivering climate resilience and enabling a circular economy.

We know that technology alone will not be sufficient to address these tremendous challenges. Our work proves that the way forward must be people-led and technology-enabled. By addressing the human and organisational factors, as well as delivering the core technical solutions, the promised benefits become attainable. This is why the Gemini Papers map out a socio-technical change programme, which is unprecedented in its ambition to use 'Data for the public good.'

Together we have laid a good foundation. Now there is both the opportunity and the need to take it further. We call on leaders and practitioners across industry, government, and academia to build on the foundation, guided by the Gemini Papers, to drive the socio-technical change programme we need and to take us forward to a better future.

Alexandra Bolton

Executive Director of the Centre for Digital Built Britain

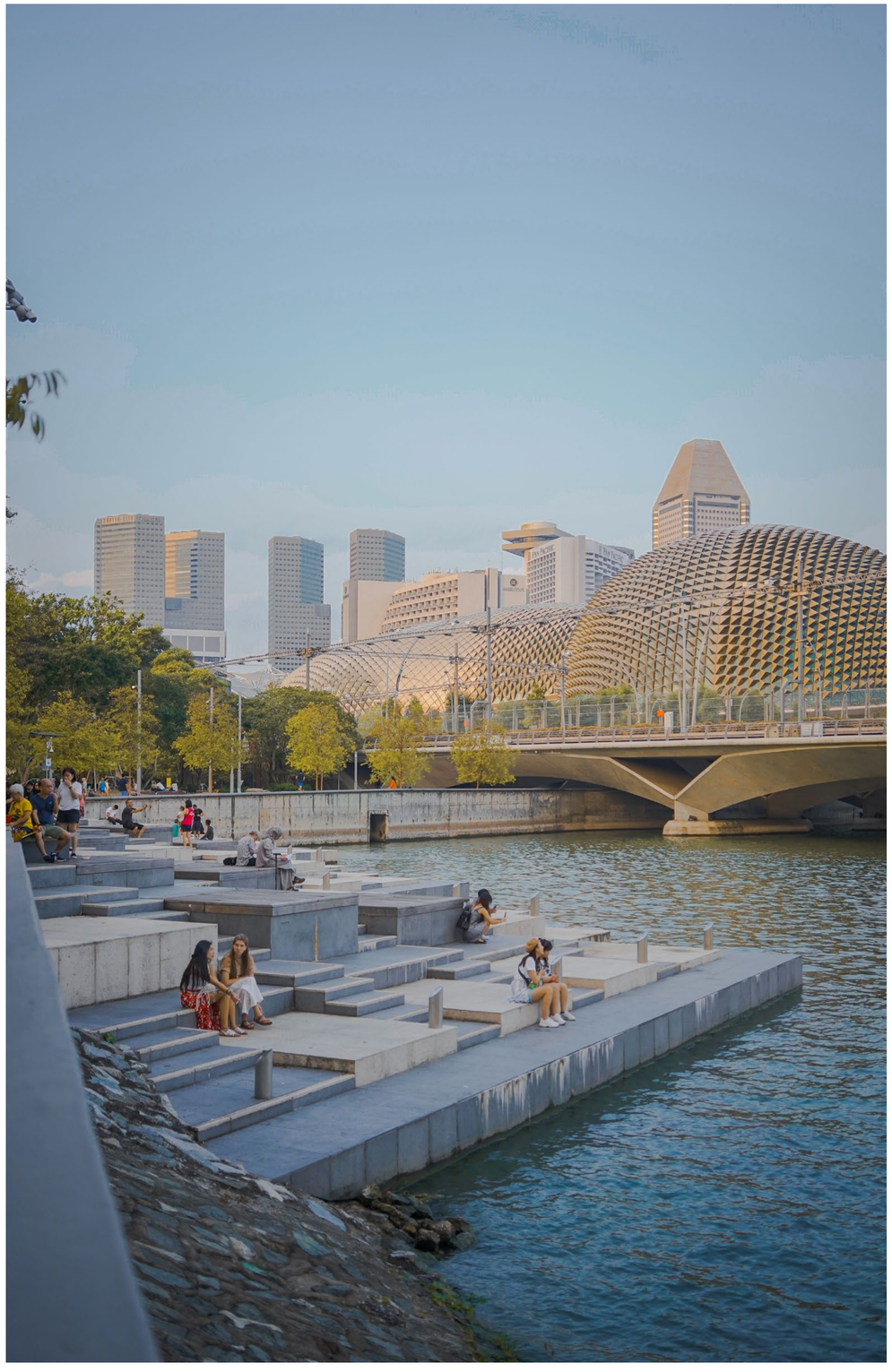
The Gemini Papers are our blueprint for the future. They lay out a body of evidence forged through years of collaboration and co-operation. They detail a case for change that brings fresh thinking and new approaches to one of our society's most intractable problems: How can we ensure people and nature flourish together for generations to come?

Over the past five years, the Centre for Digital Built Britain and its partners have been on a journey to answer this question. The Gemini Papers build on our key findings and contributions to present a way forward through the creation of ecosystems of connected digital twins.

The three Gemini Papers respectively step through the What, Why and How of this approach, showing the game-changing power of connected digital twins to help us all navigate an uncertain future.

The case for change is clear and the foundational work is now in place. We know what we must all do, and we know why we must do it. We now have a community working together in an unprecedented way to ensure data for the public good.

This is CDBB's legacy from the past five years, I hope you use it as your blueprint for the future.

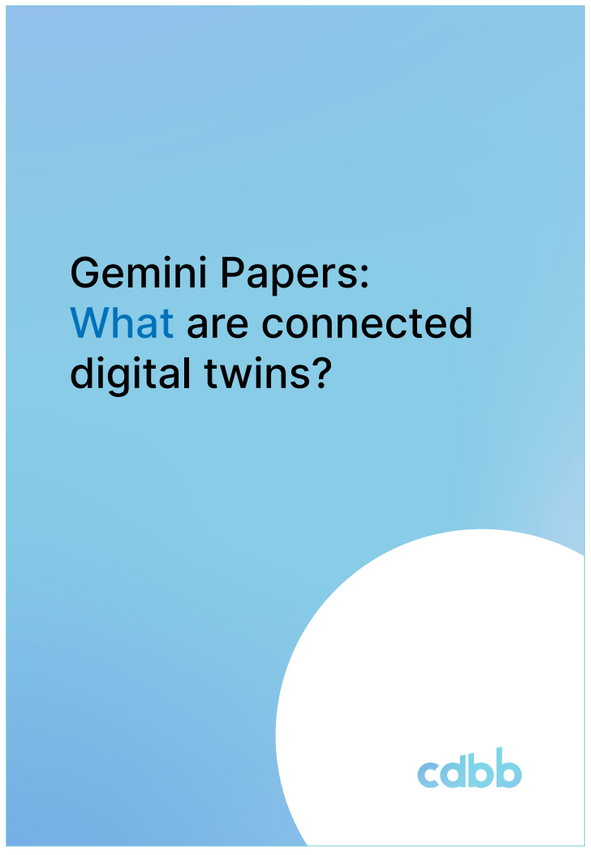


Together the three Gemini Papers address the What, Why and How of ecosystems of connected digital twins

They address the ways in which we can collectively break down silos in decision-making at all levels and make better decisions faster.

Gemini Papers: What are connected digital twins?

This paper shows that connected digital twins build out their full potential by establishing federated networks of digital twins that reach beyond organisational and sectoral silos. They connect processes, information and organisations to deliver positive outcomes for people, society, and nature.



What you need to know:

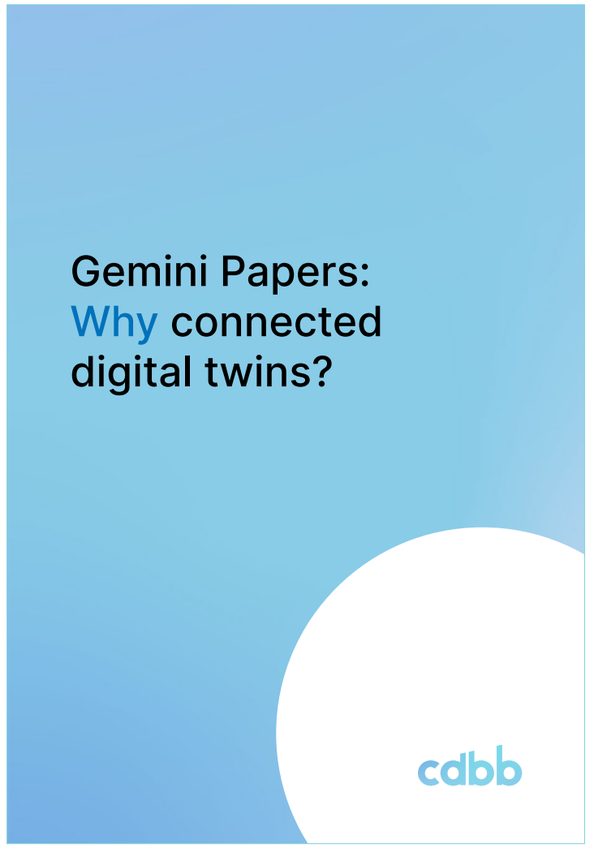
- The established concept of digital twins uses data from the physical world to unlock improved decision-making.
- The Gemini Principles ensure digital twins are developed with purpose, trust, and function at their core.
- Connected digital twins are digital twins that share information across organisational and sectoral boundaries through a common framework.
- By creating an ecosystem of connected digital twins, we can make strategic decisions that consider entire systems and drive positive change.

What must happen next

- The information value chain of a digital twin should always be present. Government and the built environment sector must champion the use of an accessible and common framework for an ecosystem of connected digital twins. This framework should create shared data connections between digital twins that will span organisations, sectors, and structures.
- The built and natural environment systems have fast become complex and difficult to understand. Policy makers and industry must ensure a network of digital twins can continue to develop as these systems grow and adapt.
- Thought leaders and influencers should ensure a digital twin is not defined too closely. By applying a narrow definition, we risk excluding possible use cases while the technology is still maturing within the construction industry. We know that digital twins are varied and should be fit for purpose.

Gemini Papers: Why connected digital twins?

This paper shows why connected digital twins are needed, demonstrating their potential to address the climate crisis and other systemic challenges by offering an informed perspective to enable maximal efficiency, resilience and the flourishing of society and nature.



What you need to know:

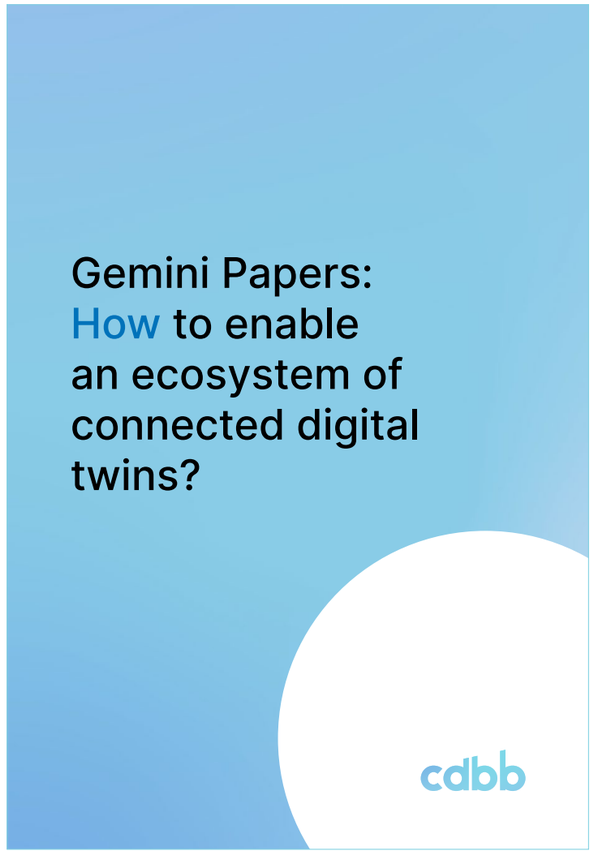
- Technology alone is not the solution to the challenges we face, but technology applied wisely is a key enabler.
- Every £1 invested in information management could potentially secure up to £6 of labour time savings while boosting government efforts to reach net zero carbon emissions by 2050.[28]
- Having a common framework for data sharing reduces the time and cost of reusing data and maintaining connections between data systems.
- Connected digital twins are a potent tool to understand the entire picture of the built environment and the social and environmental layers with which it intersects.

What must happen next

- When designing and operating connected digital twins, all parties and partners in the built environment sector must maximise positive outcomes for people and nature.
- The built environment sector must fully embrace sustainable development. Interventions in the built environment should avoid short term objectives that may compromise the resilience of future generations.
- The built environment sector must ensure interventions unlock more value from existing infrastructure.
- Decision-makers in government, industry and academia must share responsibility for ensuring the technologies being implemented today are people-led and designed with inclusion at the core. Technologies should benefit everyone equally.

Gemini Papers: How to enable an ecosystem of connected digital twins?

This paper details the blueprint for enabling ecosystems of connected digital twins and urges the need for socio-technical change.



What you need to know:

- The foundational work is in place, but the full extent of the possible through ecosystems of connected digital twins is still undiscovered.
- The establishment of an ecosystem of connected digital twins that delivers public good will only occur through a coordinated industry wide socio-technical change programme.
- Action is needed at individual, organisational, sectoral, national, and international levels.
- The right culture, delivery vehicle, value and resources are required to share data, collaborate, coordinate, and align across the sectors of industry, academia, and government.

What must happen next

- Industry, government, and education institutions must develop the National Capability Enhancement Programme, Information Management, Skills and Competency frameworks.
- Policy makers and industry must support the adoption of international standards on knowledge sharing, collaboration, and organisational relations.
- Policy makers and the built environment sector must encourage the market to flourish by updating legal frameworks and industry regulations, and developing new commercial models.
- The built environment sector must continue to embrace a collaborative environment and infrastructure to support lessons learned, best practice, guidance, and other knowledge sharing.

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