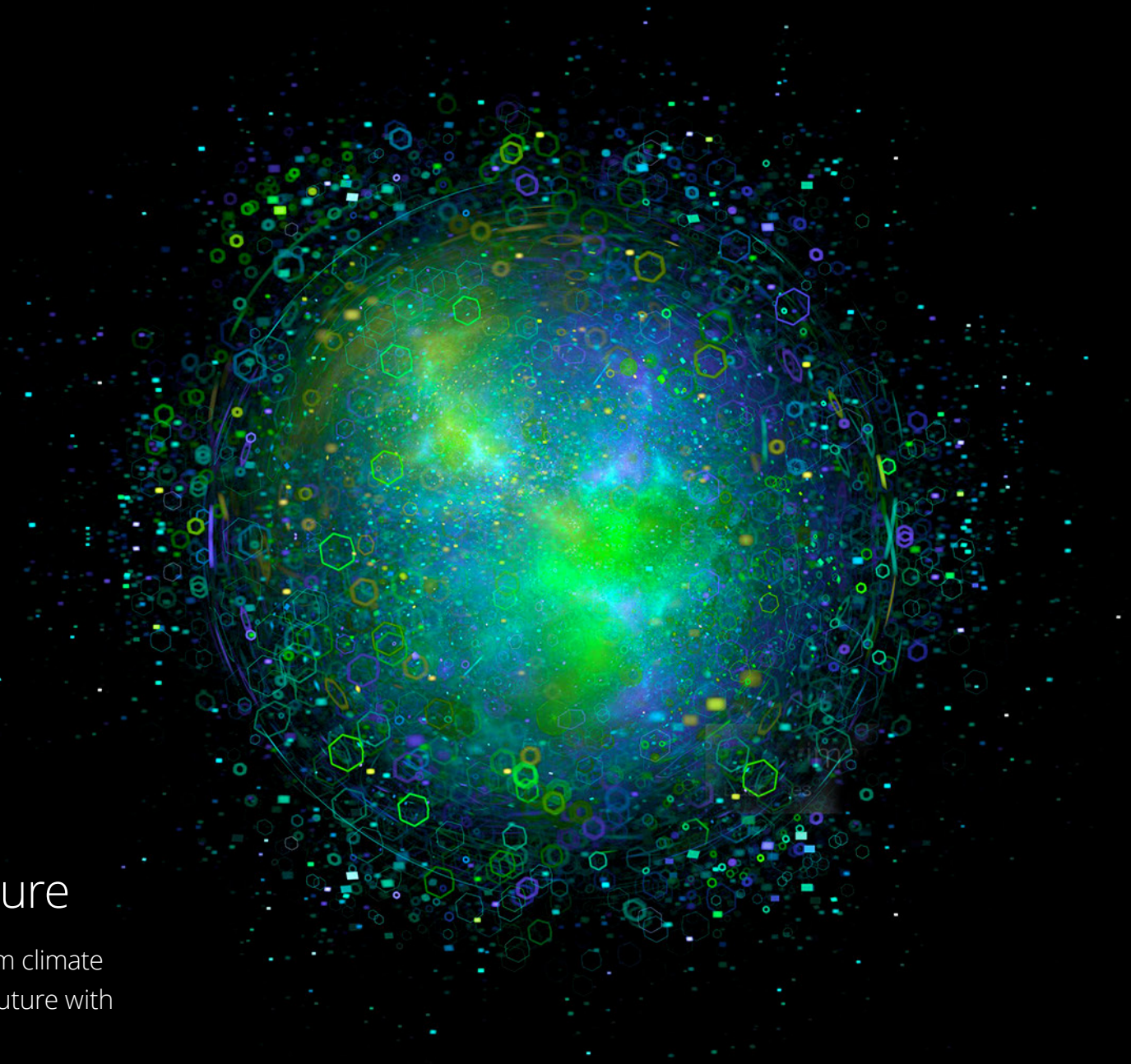
Deloitte.



Where physical and digital meet
Digital Twin for Resilient Infrastructure

Protecting public infrastructure from climate risks and creating a more resilient future with digital twin solutions

Digital twins

Climate change is the challenge of our time—and organizations have never had better data to help them understand and overcome the risk that it brings. Four out of five organization leaders now see the world at a climate change tipping point, with many optimistic that taking immediate action can help limit the impacts of climate change.*

Mitigating risks and ensuring infrastructure resilience will likely demand an ability to address the complexities that come with burgeoning data. Meanwhile, budgetary constraints can also add a layer of complexity to the challenge.

Increasingly, digital twin solutions offer an effective way forward—allowing government organizations to quickly turn complex data into insights that can drive greater efficiencies, more effective decision-making, and more meaningful actions now. As the technology has matured, digital twins have become an enabler of big ideas, helping organizations to pilot concepts or to start small and then scale fast—so they can build confidence in decisions involving large capital outlays, for example.

* Deloitte 2022 CxO Sustainability Report

More than meets the eye

Many organizations already have digital models of their physical assets and environments. Advanced digital twin capabilities can build on those elements—potentially integrating dynamic modeling capabilities, artificial intelligence (AI), automation, and other functionality. Ultimately, a digital twin could, for example, give a better understanding of past, current, and potential future realities—to support better planning, decision-making, and action. Or it could reveal the interdependencies between projects, the cascading impact of events, and other insights necessary for boosting infrastructure resilience to climate change.

For policymakers, an advanced digital twin can bolster existing efforts and capabilities, especially in the context of climate and infrastructure. A digital twin can be much different from simulation and modeling capabilities, which have been around for decades—going beyond the purpose-built models that an engineering or architectural organization may use for a specific project. A modern digital twin can address 2D and 3D spaces, as well as the aspect of time—historical data, real-time observations, trends, forecasts, and predictions. It can allow for simulation as well as dynamic scenario prediction, creation, and exploration—so you can see, modify, and assess possibilities.

To enable such capabilities, a digital twin may depend on a wealth of data sources—such as economic, climate, and social/demographic data, as well as data derived from sensors and networks. But for infrastructure and climate needs, a digital twin will typically also rely on physics models and technologies for expressing and modeling data in 3D space and over time.

A digital twin can be much different from simulation and modeling capabilities, which have been around for decades—going beyond the purpose-built models that an engineering or architectural organization may use for a specific project.

Putting a digital twin to use

What exactly is a digital twin and how can you use one to support your objectives when it comes to climate and infrastructure? A digital twin can cover multiple applications or use cases to provide context for a range of requirements. There are typically three predominant areas of use:

1

Planning, scenario planning, and design

Simulation and modeling applications can ingest broad data sets (e.g., weather, climate, demographics, economics) and test scenarios for events, such as rising sea levels or increasing storm severity or frequency, to understand the impact of these disruptions on existing or planned infrastructure. One example of this type of application is Deloitte's FutureScape™, which is a predictive intelligence solution with AI-powered simulation for massive-scale systems.

2

Operational planning and scheduling

Simulation and modeling applications can also be used to cover a shorter time horizon (e.g., daily to monthly)—as a planning support twin. Such a solution might ingest a broad range of asset and operational data (e.g., historical and sensor-based) as well as other data such as weather data to support asset optimization, schedule optimization, and similar needs. For public infrastructure needs, this type of use could support emergency preparedness and response to climate events, modeling past weather events on existing/built infrastructure, for example—while integrating a robust physics model and asset condition data, for effective simulation. Relevant solutions include offerings such a Deloitte's Motion E, an AI-enabled decision-making solution for transport operations.

Putting a digital twin to use

3

Operational decision support

As more of a "situational awareness" digital twin, this application represents the newest family of digital twins, focused on near-term or immediate decision support and decision optimization. These twins can address time horizons on the order of minute/hour/day of, as well as minute/hour/day before. Integrating IoT and sensor data, combined with broader data sets and real-world physics models/engines, can provide real-time or near-real-time information to support operational decision-making. Emergency response is one use case—with a digital twin solution deployed in a control center to optimize deployment of resources and to anticipate breaches or asset failures earlier. Deloitte's OptimalReality solution is one example that can support such capabilities—based on simulation techniques pioneered in Formula One racing.

This type of a digital twin application requires increasingly more data as well as more robust algorithms and models to produce meaningful information. In an ideal scenario or future possibility, an integrated digital twin might include features of all three twin types in one platform.

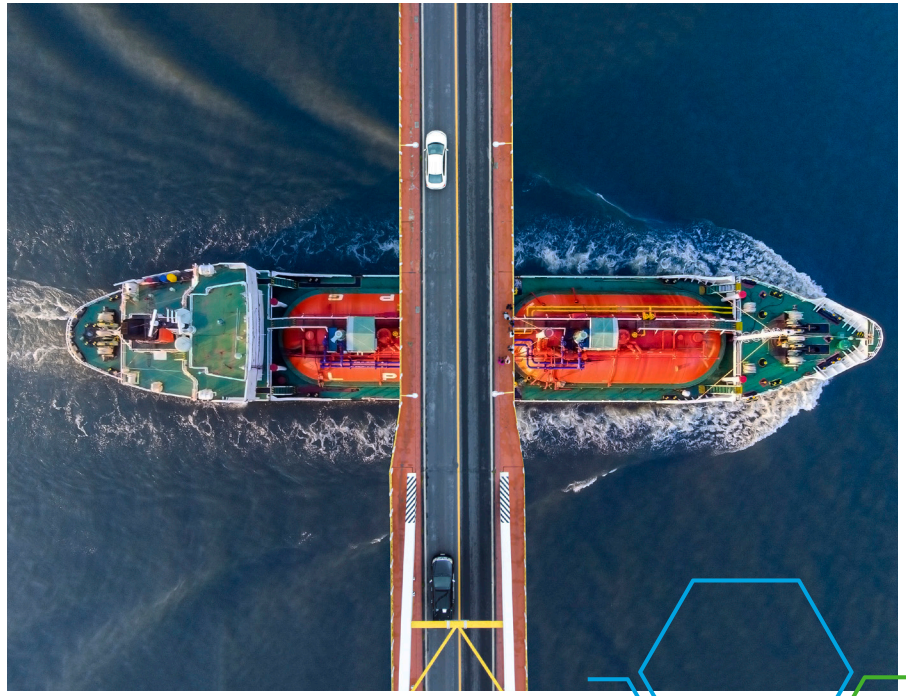
See sooner

Because it represents the real world in a digital environment, an advanced digital twin could allow planners to explore alternatives, identify failure points, and assess performance—all before anything is constructed or policy implemented. That "real world" might encompass physical things such as planes, train systems, or cities, as well as less tangible assets such as financial systems or telecommunications networks.

Enabling resilience: Moving forward with digital twins

A number of factors make digital twin capabilities compelling for infrastructure needs. As the climate challenge intensifies, these forces will drive government organizations of all sizes to rethink how they use technology to serve citizens and fulfill their missions.

A digital twin can be an important enabler of resilience—allowing you to understand, model, and plan at a more detailed level, using historical, current, and predictive data. When deployed as an integrated solution, it allows you to address resilience needs on a larger scale. It can help reduce guesswork, allowing you to test hypotheses and make planning and design assumptions more transparent and visible—so you can run more effective and robust scenarios that improve planning and preparedness. Before you can effectively leverage a digital twin as a resilience enabler, you likely will need to address key questions about data, design, and applications.



Before you can effectively leverage a digital twin as a resilience enabler, you likely will need to address key questions about data, design, and applications.

Enabling resilience: Moving forward with digital twins

Data

At the intersection of infrastructure, resilience, and environment, the data can be overwhelming. Not only are there massive amounts, it can also reside in many places, making it difficult to get clear and consolidated insights to support effective decision-making. While a digital twin does not solve data or data volume challenges, leaders can be better prepared to answer questions such as:

- How much data do we really need?
- How much data do we have?
- Is the data defined consistently across uses, applications, and stakeholders?
- Is this the right data for the insight and use case we are solving for?
- Are the aggregation models and algorithms translating the data into meaningful information?

Design

How you put together the pieces of a digital twin may depend on many factors—from budget to technological talent to public priorities. As you move forward, it can help to think of an effective digital twin design in three ways:

- As a data platform that encourages data sharing and use of common data
- As a modeling platform that encourages use of common algorithms and physical/economic/social models
- As a visualization platform that standardizes how information is represented and presented to different user communities

Applications

Use cases for digital twins are growing, and they are becoming well-documented in the commercial sector—including use of real-time and historic race data to improve performance in Formula One car racing or supporting manufacturing automation for pharmaceuticals. Other real-world applications in which Deloitte has been involved include enhancing air traffic management and tire management for fleet operations. Applying imagination as well as an understanding of what is possible can help you create a vision for digital twins and the specific applications that will matter to your stakeholders.

Finding your focus

Leveraging digital twins to address climate and infrastructure resilience needs is more than an exercise in technology. Ultimately, while it is about infrastructure asset care, it is also about protecting human lives, the natural environment, and the economy, as well as supporting effective and timely decision-making that serves people, communities, and the planet. A few questions that may rise to the top for policymakers:

How will electric and autonomous vehicles define the future of mobility and affect infrastructure?

How will our roads function if temperatures rise?

Are our critical transport routes at risk from fires and flooding?

What will emergency response look like in a changing world?

What is the optimal approach to address human and climate-related needs?

Seeing double:
What a twin looks like in action

Here are just a few examples of how digital twin technologies can help support greater infrastructure resilience in the face of ongoing climate change.

Grid infrastructure/energy modeling

Electric vehicles, net-zero buildings, changing demographics, renewables, and other factors—they all bring new demands and expectations for the energy grid and its future. Digital twin solutions can help utilities actively monitor and manage energy distribution—to enable dynamic distribution. Planners can explore the effects that potential actions will have on grid congestion, such as consumer rate changes or changes in consumption times. They can also ask and answer questions about growing loads and the investments they will need to make infrastructure resilient or to balance loads, including decisions related to transportation services and building development.

Land management

Land and infrastructure go hand in hand. Infrastructure exists as part of both built and natural environments—presenting a host of intertwining decisions that a digital twin can help you make. With digital twin solutions, for example, you can more readily see how natural land can help developed land remain resilient. A prime example: modeling extreme weather event (e.g., tropical cyclone) buffer regions adjacent to developed or developable land, to plan for stronger future storms and increased flooding. Digital twins also can support routine land-infrastructure management needs, such as use plans for airports, or planning/servicing sewer lines and the public greenways that often sit on top of them.

Digital twins also can support routine land-infrastructure management needs, such as use plans for airports, or planning/servicing sewer lines and the public greenways that often sit on top of them.

Asset lifecycle management

Data is changing the asset management game every day—providing more variables, more meaningful inputs, and a more granular view into statuses and simulations. In fact, rigorously collecting asset data in a structured way can help you prepare for future benefits, using the data when twins reach higher levels of maturity. One big potential payoff lies in using data-driven digital twin insights in the upfront investment decision-making for assets.

Whether in pre-design or design, construction, or operation stage, there are some questions a digital twin can help you gain clarity and confidence with during infrastructure investment decisions:

- What is your five-year upgrade plan?
- What are your priorities?
- What impact does an investment have on adjacent assets?
- What roles will the finance, planning, engineering, maintenance, and operations functions have to play?

Predictive maintenance

By helping you assess asset degradation and predict asset needs, digital twins offer a path to greater asset efficiency and reduced consumption. Potentially, you could proactively maintain assets, prevent issues, and make assets last longer. As part of the predictive maintenance vision, digital twins can also enable augmented reality (AR)-assisted maintenance—so people working on or inspecting a bridge, for example, can access structural data and related information, to help them do their jobs better—optimizing for resilience as they build or maintain infrastructure.

Transit planning and management

Increasingly intense rain events and aging structures make transit systems more prone to flooding. With historical climate/weather data, future trend data, and historical data on system floods, you can identify the trigger event, potentially affected locations, and develop a plan for how to respond. Do you close areas in advance? Do you use real-time sensors to make decisions on the fly? A digital twin can let you predict the frequency and make action plans.

Wildfire planning and response

A digital twin would allow dynamic assessment of fire risk, accounting for changes in development, hazard mitigation efforts, and other factors. Organizations could use a digital twin solution to examine risks given specific weather or climate conditions, or new development and construction activities. It could also be used to look at the impact of policies affecting risk or development patterns.

With historical climate/weather data, future trend data, and historical data on system floods, you can identify the trigger event, potentially affected locations, and develop a plan for how to respond.

Routine projects

Digital twins can bring climate resilience advantages for even seemingly small or run-of-the-mill projects. One example: Using a digital twin to explore rainfall scenarios can inform a culvert replacement program and help prioritize the actions that can prevent a road from washing out.

Network optimization

Enabled by AI, a digital twin can solve complex problems with many moving pieces and possibilities. It can help optimize processes or networks—such as air traffic in the event of more frequent storms—to see millions of permutations and provide options for planning and response. For roads, it also could predict where congestion will occur before it happens—key in climate-related evacuation scenarios.

Using a digital twin to explore rainfall scenarios can inform a culvert replacement program and help prioritize the actions that can prevent a road from washing out.

Getting more value from your technology investment

The urgency and speed of climate change means there is no time for trial and error in the physical world—no time for physical pilot projects that take years to test a hypothesis about infrastructure and its resilience.

How can you determine the potential value that can come with a digital twin? One way to think about it: as perhaps a necessary investment for informing resilient infrastructure planning and operations

Consider digital twin use cases for light rail—from two points of view, with two different twins and two different sets of outcomes.

- For *existing* rail transit operations, a digital twin could help you optimize operations, operational decisions, and asset management—allowing you to delay or defer the building of new physical rail transit infrastructure.
- For infrastructure *planning*, a digital twin could inform optimal placement of new rail transit assets that take into account not just geographic and technical considerations, but also land use and economic/social factors. One potential end result: You could improve the social and economic profile of an investment as well as reduce time to benefit.

How can you determine the potential value that can come with a digital twin?

To get more value from digital twins, organizations should understand and embrace a few leading practices—to help drive greater infrastructure resilience and serve communities better.

- **Know your vision** and your vision for climate change. What are you building toward?
- **Think digital from the start**—before, during, and after design of the physical asset.
- **Go beyond one-off initiatives.** Build systemic change into how you do things, while keeping risk reduction top-of-mind for all your efforts.
- **Put human context into the data.** Don't just see that blinking red dot on the map. See the people and communities, too. Why is it red? Who is affected? Also, seek out data and needs for traditionally overlooked communities. Make those communities part of your resilience planning.
- **Bring things into a spatial context**—with layers of data that connect people, places, and experiences.
- **As you build, build toward a single, integrated platform**—and keep integrating as you enhance and extend your digital twin.
- **Know your data.** How old is it? Where did it come from? Is it complete? It will drive your digital twin model. Make sure it is robust, accurate, and useful. Include future-looking data, too. Get common definitions in place and use the latest data methodologies.
- **Use a digital twin as a tool** to inform your stakeholders and make them part of the decision-making process. Doing so can help ensure you are not missing data (e.g., sentiment) or overlooking communities. The approach can also allow stakeholders such as businesses make better climate-related/resilience decisions—like where to locate a new factory.
- **Know that not all assets are equal.** How essential are certain roads? Do they take people to hospitals? Which assets matter? Do you plan alternates or build new ones? Ask critical questions to ensure you are devoting adequate energy and resources to the challenges that matter most.
- **Create a culture of climate risk** that goes beyond those who build and actively maintain the infrastructure.
- **Break out of "compliance culture"**—to put new tools to full use. One possible step to take: Proactively share insights from your digital twin with colleagues—to demonstrate the potential and inspire them to take action with digital twins.
- **Measure your impact**—through financial assessments and other analyses. And be sure you can estimate future impact as you work to plan, schedule, and prioritize projects in a strategic way

How we can help

Climate change, infrastructure resilience, and digital twins—each, on its own, represents a complex challenge. Put them all together, and the complexity can feel overwhelming. Deloitte brings a strategic, holistic approach to problem-solving, supported by a diverse skillset, worldwide network of professionals, and capabilities across the Advise-Implement-Operate spectrum.

When it comes to climate and infrastructure, Deloitte goes beyond what you might expect from a professional services firm, a systems integrator, or an architectural and engineering firm—with outcomes-focused perspective centered on what you want to achieve and, holistically, what it will take.

Capabilities and experience

To enable digital twins that can support infrastructure resilience, we show up with real-world-tested frameworks and offerings that can help you move efficiently. And they are all driven by our insights in government, regulatory affairs, technology, data, finance, sustainability, and more.

We can also do the hands-on work of creating, supporting, and operating digital twin environments—providing specific capabilities such as managing data, defining KPIs, integrating systems, monitoring assets, and running solutions. And our deep experience with large-scale data analytics and interpretation, financial analytics, and AI is just one of the things that sets us apart.

Solutions

We have developed and are constantly expanding our own portfolio of solutions that can support the climate-related infrastructure-resilience needs of clients. It's an extensive and growing set of solutions naturally geared toward digital twin applications. It includes asset-model integration tools, portfolio management solutions, future-facing "what if" and scenario-planning apps, and solutions that can help you add the carbon emissions "dimension" to infrastructure planning.

Vision

Through Deloitte labs and centers of excellence—such as our Center for AI and AI Institute—we can help you explore the art of the possible. Our specialists deeply understand how organizations operate and how they can operate better by leveraging the latest innovations to solve real-world needs. Through immersive experiences in our labs and innovation centers, we can show you what digital twins look like today, how they might look tomorrow, and how you can apply them to your specific needs.

Purpose

Deloitte is a purpose-driven organization where making a positive impact on the world is embedded in our ethos. We have established ambitious, achievable goals for ESG, DEI, and SDGs both internally and within the work with do externally with clients.

Through Deloitte labs and centers of excellence—such as our Center for AI and AI Institute—we can help you explore the art of the possible.

So what's next?

The realities of climate change are changing by the day. Time is critical. Insights are critical. Taking action is critical. So how will you make maximum use of the time available, to generate the insights you need for driving more meaningful action—for making your infrastructure more resilient?

No matter where you are in the journey of climate change and digital twins, Deloitte can help. Whether you want to address one specific challenge or build a bold future vision of resilient infrastructure supported by digital twins, we can provide the ideas, insights, and solutions to help you move forward with confidence.

Contact us to learn more about our capabilities, schedule a demo, or discuss a specific challenge your organization is facing.

Contacts

Dr. Kellie Nuttall
Partner, Deloitte Australia
knuttall@deloitte.com.au
+61 7 3308 7075

Andrew Pau
Partner, Deloitte Canada
apau@deloitte.ca
+1 604 640 3295

James Cranswick
Director, Deloitte UK
jcranswick@deloitte.co.uk
+44 20 7007 1180

Anant Dinamani
Partner, Deloitte US
adinamani@deloitte.com
+1 241 840 7698

Deloitte.

To find out more, please visit **www.deloitte.com/us/AI**.

About Deloitte