

New uses for digital twins in the race to navigate an uncertain future

As business decisions become increasingly complex, digital twins are being reimagined to simulate key strategy decisions and help businesses better navigate uncertainty

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In the high-octane world of Formula 1 racing, where milliseconds can separate triumph from defeat, teams face relentless pressure to outperform on every conceivable front. Engineers work under tight budgets and even tighter schedules to design some of the fastest cars on the planet. Yet, the real challenge begins even before these cars hit the racetrack. With limited opportunities to test these complex designs in real-world race conditions, compounded by regulatory considerations regarding on-track testing, F1 teams are turning to an innovative solution: digital twins.

Digital twins, which are virtual replicas of systems or processes, have revolutionized how teams navigate the uncertainty of car performance under race conditions. By creating and utilizing these comprehensive simulations,

teams can explore the behavior of every component—from brake systems to aerodynamics—without the physical car ever leaving the garage.

Now, with more data available than ever before, F1 teams are using digital twins to address a new realm of uncertainty: race-day strategy.¹ Through the collection of newly accessible track, team, and driver data, teams are using these technologies to simulate how each of their competitors might approach race day, allowing them to build a strategy that reduces competitor uncertainty and at its pinnacle, paves the way for a clearer path to victory.

Of course, winning a race is different from managing a large enterprise where the “season” never ends, and no one gets the official title of “champion.” But just as race teams are now using digital twins to simulate and model complex strategies, organizations also have an opportunity to reimagine digital twins as a tool for strategic decision-making.²

Advancements in technology such as the emergence of generative AI, increased cloud computing power, and greater access to data have created new prospects for digital twins beyond their traditional operational use cases. By combining digital twin technology with simulation-powered methods, organizations can shift their strategic decision-making methods from a deterministic to a probabilistic approach, meaning, from a single, fixed strategy based on known inputs to a more flexible strategy that is continuously refined based on simulated outcomes and emerging data. This evolution toward probabilistic simulations can help business leaders more fully grasp the potential impact of various factors and plan for events where

The dynamic duo: Digital twins and simulations

Digital twins and simulations are two halves of the same coin, working together to create a powerful tool for understanding and optimizing complex systems. Think of a digital twin as a highly detailed blueprint—a digital replica of a physical or an abstract system. This replica, built through robust mapping of the real-world counterpart, provides the foundation for running

they need to balance multiple—and sometimes competing—objectives.

But the question remains: Are digital twin simulations equipped to address these new vistas of uncertainty?

To better answer this question, we interviewed a number of senior leaders from different countries with experience in strategy, consulting, product management, and digital twin architecture to explore how these technologies are empowering businesses to go beyond more straightforward operational use cases and confront strategic uncertainties head-on (see [methodology](#)). This research identified four unique applications of digital twins based on whether the applications are related to operational versus strategic decisions, and whether they relate to closed (controlled) environments versus open (interconnected) environments. While operational uses of digital twins are well-documented, applications focused on strategy are new evolutions. Here, we explore these applications in particular, the common business problems they can help address, and the opportunities and challenges that leaders may need to navigate to optimize their decision-making.

sophisticated simulations. Using methods like Monte Carlo³, agent-based modeling⁴, or discrete event simulation⁵, these simulations allow organizations to test different scenarios in dynamic and comprehensive ways, revealing potential outcomes, identifying vulnerabilities, and ultimately informing better decisions. While the digital twin provides a detailed representation of an object or system, it's the simulation that unlocks its true value, transforming a static replica into a dynamic tool for exploration and optimization.

What's prompting the novel use of digital twins for strategic decision-making?

In the past, operational use cases were the most attainable and actionable frontier for digital twins. The data was contained, and the end result led to clear and measurable efficiency gains. For example, digital twins that mirror physical assets on a factory floor can be used to assess the health of a piece of machinery or simulate supply chain

management for optimizing production and driving cost efficiencies.⁶ However, when we shift the use cases to more strategic endeavors, data and outcomes are not always as straightforward.

If a company wants to deploy a digital twin to simulate the performance of a new product, for example, a factory can easily embed a sensor on real physical parts and machinery to better monitor production. But capturing consumer sentiment and preferences isn't quite as easy. Beyond figuring out how to capture sentiment, organizations should also consider data privacy regulations and standards, competitor reactions, and the potential for supply or environmental disruptions. These "open systems" come with a level of uncertainty not found in the "closed systems" of a smart factory floor.

Our interviewees identified several recent trends that are shifting the landscape and creating new opportunities and motivations to deploy these technologies for more strategic and sophisticated problems:

- **Data is more available than ever before.** The emergence of connected devices and cloud computing, along with advancements in AI and machine learning, has led to greater proliferation of data in recent years. "This technological evolution enables us to not only replicate systems and processes in real time but also to predict future conditions and make autonomous decisions," says the head of digital twins for a German technology company. They also pointed to the impact that greater AI capabilities have had on improving model outcomes in manufacturing, health care, and urban planning.
- **The sheer volume of risks is too big to ignore.** Rapid change and volatility in the business landscape have increased the demand for flexibility in decision making. Digital twin simulations can assist with modeling and comparing different scenarios to help ascertain the impact of decisions under conditions of uncertainty. Consider, for example, the impact of climate on key business decisions where a digital twin consultant from Saudi Arabia discusses a project that used digital twins to simulate the impact of potential floods: "In cases like Jeddah, where

unexpected rainfall led to significant flooding and casualties, digital twins have been used to simulate rainfall impact and flood dynamics across the city. These simulations can help city planners to implement effective flood management strategies and emergency response plans, reducing potential damage and improving safety.”

- **The financial stakes are higher than they have been in over 15 years.**⁷ The higher cost of capital⁸ and investor pressure for returns have intensified the need for more rigorous scenario planning and risk assessment. Digital twins can help align business decisions with financial objectives and predict their likelihood of success. According to a strategic simulation lead in the United Kingdom, investors are currently cautious about securing the best returns from their investments, and thus “being able to demonstrate an understanding of the probability of your success is helpful to secure that investor capital.”
- **Culturally, more are ready to embrace data-driven decision-making.** There has been a cultural shift towards data-based decision-making, fostering a greater reliance on advanced analytical tools. As a digital twin director at a UK media and telecommunications company explains, “In the last 10 to 15 years, the people who entered the workforce are more data literate and more willing to actually experiment with data.” This, along with a new generation of leaders that are more focused on analytical decisions and more confident in using data for their decision-making process, creates the cultural space to embrace simulation-type analyses as well.

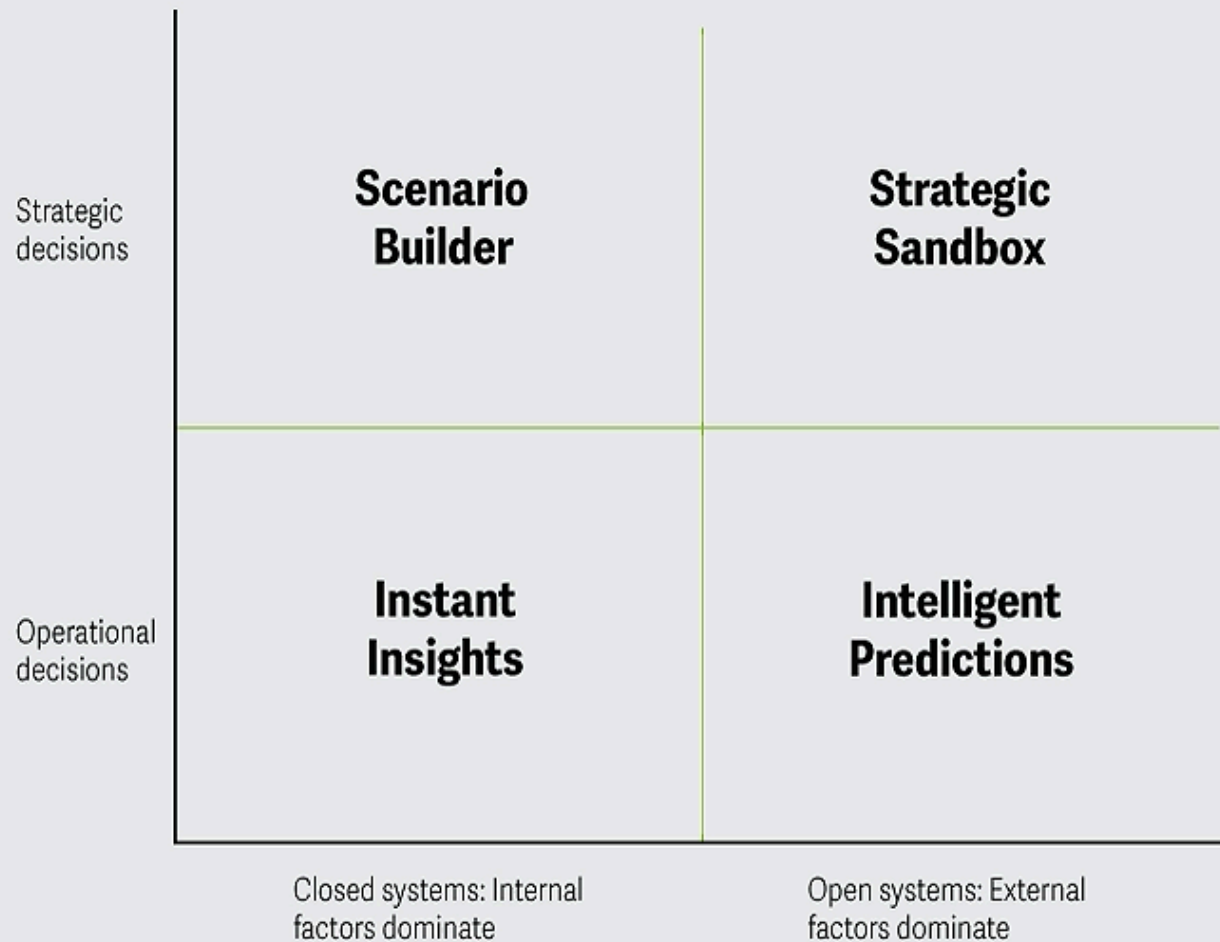
Designing strategy for an uncertain world: The digital twin simulation matrix

As the landscape of data and technology evolves, so do the decisions made within organizations. Our interviews uncovered an exciting link between these decisions and different uses of digital twin simulations. From these discussions, we've pinpointed four unique applications of digital twin technologies, considering whether they align

with operational or strategic decisions, and whether they operate within closed- or open-system environments (figure 1).

Figure 1

Four applications for digital twins



Source: Deloitte analysis.

At the intersection of operational decisions and closed systems we find “Instant Insights” providing information on current performance levels. Gaining insights into the current performance of physical assets is one of the most well-documented applications of digital twins. Across our interviews, experts point to the primary benefit being the ability to achieve almost instant insights—sometimes even before the asset (such as a piece of machinery or equipment) is deployed in the physical world. In this setting, digital twins can serve as powerful tools for monitoring and detecting potential deviations from expected performance levels, while providing recommendations for addressing deviations and scheduling necessary maintenance to decrease downtime and increase productivity.

Going one step further on the operational scale, “Intelligent Predictions” seek to assist with similar, operational decisions but involve more data from the external environment in the process. An example could be a digital twin of a city’s traffic system, which uses real-time data from various sources (such as traffic signals, weather, events, etc.) to optimize traffic flow and signal timings. The decisions are operational in nature (like changing signal timings), but the system is open as it’s influenced by various external factors. In addition, what distinguishes these applications from “Instant Insights” is that these types of simulations can be used to go beyond the monitoring of current performance levels to identify patterns and trends that can predict future outcomes. As such, simulations at this level can help forecast—rather than only detect—potential disruptions ahead of time to better identify the best course of action to mitigate disruptions.

But where digital twins are venturing into new territory is in the upper quadrants of the matrix, where we find the “Scenario Builder” which can help with planning different types of decisions in different scenarios, and “Strategic Sandbox” simulations in open systems that help businesses navigate the highest levels of uncertainty. These applications build on the foundational capabilities of the operational use cases to open new possibilities for improved strategic decision making, but their implementation is not without its challenges.

Scenario Builder

Starting at this level, more strategic, rather than operational, use cases emerge. And by no coincidence, the complexity of business problems levels up as well. The decisions here are strategic in nature (for example, changing the pricing strategy of a product), but the system is closed as the factors influencing the decisions are primarily internal to the company. With decisions becoming more complex, these tools can help organizations plan for different futures and different possible scenarios, allowing leaders to gain a deeper understanding of the potential impacts and consequences of their strategic choices.

For instance, a global consumer goods company used a digital twin as a training tool for its marketers.⁹ By leveraging existing customer data, the replica simulated how decisions like advertising on certain channels would impact the overall return on investment of a marketing campaign. The organization gamified the marketing launch to prepare its marketers to more seamlessly react to any number of potential scenarios, allowing them to experiment with different approaches for targeting specific customer segments. The marketers were able to observe the resulting effects on key performance indicators (KPIs) like conversion rates, brand awareness, and traffic generation. In the “game,” marketers were provided a budget to allocate to different channels (for instance, social, print, and direct channels) and content types (such as messages introducing the brand, highlighting product features, or providing an offer). As marketers balanced their various choices, the digital twin simulation highlighted the best set of decisions on a variety of KPIs like conversion rates, awareness, and traffic, helping them understand the tradeoffs and opportunities of a multitude of choices.

In a similar vein, the digital twin director of a media and telecommunications company in the United Kingdom talked about creating digital twins of different customer groups. By taking into consideration factors such as how long they’ve been with the company, what products they use, and whether they received any discounts, the

organization was in a much better position to create detailed customer profiles and develop more targeted marketing strategies.

Compared to traditional use cases, interviewees noted more challenges in these more strategic types of simulations. These include reliably identifying and evaluating different scenarios and managing and analyzing complex data sets. In addition, ensuring stakeholder buy-in and alignment can prove to be difficult for leaders who are not used to working with such complexities and who are expecting more clear-cut answers. To help alleviate some of these problems, the experts interviewed suggested the following actions:

- **Bring your stakeholders on the journey.** The digital twin director at the UK-based media company emphasizes the need to bring stakeholders along the development journey. “We had to go through a lot of iterations with stakeholders to get them to engage with [the model],” they say. They note that stakeholders are used to simpler graphs with a “line going up” rather than a dynamic simulation. Working with key stakeholders from the onset can help them better understand the power of these tools.
- **Focus on the most important data assets first.** While the sheer volume of data can be overwhelming, one use case shows how customer data, and specifically, the acquisition of the data, was paramount to the project’s success. For this project, a utilities company based in the United Kingdom was trying to simulate the likelihood of customers being willing to switch to greener (and more expensive) devices.¹⁰ The team commissioned a nationally representative survey to better profile customers and understand the key factors influencing their decision-making process, including aspects such as upfront investment, total cost, and government incentives. Subsequently, they integrated the survey data into the model to simulate scenarios depicting the potential evolution of these factors in various ways (for example, technology becoming more expensive; the government offering increased subsidies). This approach allowed them to run simulations using an additional data set not originally accessible in the model.

- **Feed the model with continuous real time data.** Several experts we interviewed emphasized the importance of feeding back live data to the model to help it learn from failures or real-life events and thereby improve its decision-aiding capabilities. For example, one consultant highlighted how live data, like sensor or consumer sentiment data, could potentially be the differentiating factor: “We feed that [real time information] back into the asset management system, which is used as a data source to run the decision analytics.”

Strategic Sandbox

Strategic Sandbox simulations are typically focused on higher-order strategic planning under conditions of greater uncertainty in open system environments. Given the relative novelty of utilizing digital twin simulations in such settings, the applications at this level are more limited compared to simulations used in prior levels. These include fundamental merger and acquisition decisions and key strategic decisions pertaining to capital allocations (for instance, investments in technology to improve productivity). Promisingly, the case studies in this class have produced encouraging results, pushing the limits of this technology and helping businesses become more at ease with uncertainty.

For example, a fast-moving consumer goods company used a digital twin to retroactively model a past M&A transaction for a health and well-being product.¹¹ By simulating the transaction with the digital twin and considering factors such as regulatory changes and competitor moves, they were able to reassess the original decision regarding the purchase price of the asset. The model suggested that using the digital twin at the time could have led to a lower purchase price and significant cash savings. This exercise served as a powerful proof of concept, demonstrating the potential of digital twin simulations to enhance M&A decision-making by providing a more comprehensive and realistic view of enterprise value under different scenarios.

Our interviewees envision a future where digital twins revolutionize strategic planning across various sectors.

Imagine, for instance, simulating the impact of climate change and different policy interventions or using digital

twins to model urban environments and design more equitable social policies that address issues such as overpopulation and inequalities. In addition, simulations could help business leaders design more robust and agile supply chains, model workforce dynamics, or improve customer experience by replicating customer journeys and interactions to identify and address specific pain points.

While these strategic simulations show great promise, they remain relatively novel and limited, presenting a significant opportunity for growth and innovation. As simulation technologies mature and their capabilities gain wider recognition, we anticipate a surge in innovative applications across industries. Still, as strategic simulations are not currently deeply embedded in organizations, the financial viability of such use cases can be difficult to gauge, and securing leadership buy-in to invest in these types of simulations may be a challenge. Data fidelity is lower compared to other levels of the matrix, which can pose a challenge for running strategic simulations with a great level of accuracy. In addition, there are also inherent technical challenges related to data analytics capabilities that organizations will need to address to integrate decisions across different functions. Our interviewees offered several suggestions to address these matters, including:

- **Leaning on AI to bolster data capture, including synthetic data.** By using novel technologies such as gen AI to produce synthetic data, organizations can feed digital twin simulations with enriched, forward-looking data sets. With data programmed to mirror real-world conditions, digital twin simulations can operate in more realistic environments that ultimately lead to improved decision-making.
- **Putting different models to the test.** As these models push the boundaries of how decisions are informed, it may make sense to compare the results of the simulations to more traditional means of measuring value. An urban strategy digital twin lead at a research institute in the Netherlands addressed leadership skepticism by running digital twin simulations alongside traditional methods for six months, demonstrating the consistency and accuracy of sophisticated digital twin simulations.

- **Seeking the right partnerships to turn an idea into reality.** To address computational challenges in terms of computing power, the same urban strategy digital twin lead partnered with a cloud provider to enhance their ability to produce simulations more efficiently. “This transition [to the partnership] supports our real-time and complex digital twin simulations, moving beyond the limitations of our previous infrastructure,” the interviewee emphasized.

Racing toward the next frontier of uncertainty

In today's business landscape, strategists are often confronted with unprecedented levels of uncertainty, and the ability to navigate ambiguity and make informed decisions has become a critical leadership skill. Newer technologies such as digital twins can offer valuable tools to help leaders gain deeper insights in increasingly uncertain settings, simulate diverse scenarios, and mitigate risks in decision-making processes. As digital twins become more prevalent, their ability to combine real-time and historical data will transform predictive analytics, scenario planning, and decision-making processes across industries. To help your organization prepare for the most sophisticated applications of digital twins, consider the following:

- **Prepare for transition.** While certain organizations may have been using digital twins for operational use cases, a transition to strategic use cases may require an organizational mindset shift. As noted by one digital twin lead, “People are part of the challenge. If you get lots of possibilities all at once, then some people say, ‘This cannot be true.’ It used to take months before we had all this information [to build out a comprehensive scenario analysis], and we couldn't do 10 scenarios within a day. Can the data be trusted?” Thus, by articulating the power of these models, including the speed to insights and flexibility to adjust simulations, organizations can seamlessly weave these capabilities into their organizations for more strategic use cases.

- **Build the leadership team to design an enterprise digital twin strategy.** It's crucial to establish a leadership team dedicated to designing an enterprise strategy for digital twins. As the digital twin director at a UK-based technology and media company states, "Bringing in an experienced expert by the chief digital officer to establish and lead our digital twin team has been pivotal in educating our leadership on the nuances and potential of this technology for our strategic goals."
- **Look beyond the organization to build the technical and talent infrastructure.** Organizations should look beyond their own boundaries to establish the necessary technical and talent infrastructure to support new uses for digital twins. Partnerships, particularly with leading universities, can be instrumental in attracting fresh talent and securing a pipeline of future leaders familiar with the technology, according to the digital twin lead at a Dutch research institute.

The organizations that can push their digital twins beyond operational use cases and infuse them into their most important strategic decisions can build a more resilient, adaptable, and forward-thinking enterprise that is better equipped to navigate the complexities of the modern business landscape. Just as F1 teams fine-tune their vehicles for peak performance on the racetrack, enterprises using digital twin simulations can refine their strategies to excel in the competitive business arena.

Methodology

Deloitte interviewed 12 senior leaders between May and June 2024 from organizations across industries with US\$500 million or more in annual revenue. We spoke with experts including digital twin architects, strategists, consultants, and business product managers to understand how digital twins, combined with strategic simulations, are adding value to their organization's strategy and helping them manage uncertainty. We carried out thematic analysis of the interview data and reviewed relevant literature to identify the different benefits of deploying digital twins, even in the most ambiguous of environments.

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Endnotes

1. Charlotte Hu, “[An inside look at the data powering McLaren’s F1 team](#),” *Popular Science*, May 16, 2023.

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2. Aaron Parrott and Lane Warshaw, “[Industry 4.0 and the digital twin](#),” *Deloitte Insights*, May 12, 2017.

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3. Monte Carlo Technique: This method uses computer simulations and probability distributions to estimate a range of potential outcomes for a given model. It helps leaders understand the uncertainty in their business decisions by considering different “what-if” scenarios for key factors.

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4. Agent-based modeling: This method creates a simplified virtual world to study how individual “agents” like customers or competitors interact with each other and make decisions. By observing the patterns that emerge from these interactions, leaders can gain insights into complex system behaviors and test different hypotheses.

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5. Discrete event simulation: This technique breaks down complex systems, like a manufacturing process or a customer service queue, into a series of specific events. By simulating the timing and sequence of these events, considering resource constraints and interaction rules, leaders can analyze how the system will behave over time and identify areas for improvement.

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6. Aaron Parrott, Brian Umbenhauer, and Lane Warshaw, “[Digital twins: Bridging the physical and digital](#),” *Deloitte Insights*, Jan. 15, 2020.

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7. Michael Mankins, “[Capital is expensive again. Now what?](#)” *Harvard Business Review*, March 30, 2023.

[View in Article](#)

8. Ibid.

[View in Article](#)

9. Example from Deloitte client work.

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10. Example from Deloitte client work.

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11. Example from Deloitte client work.

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