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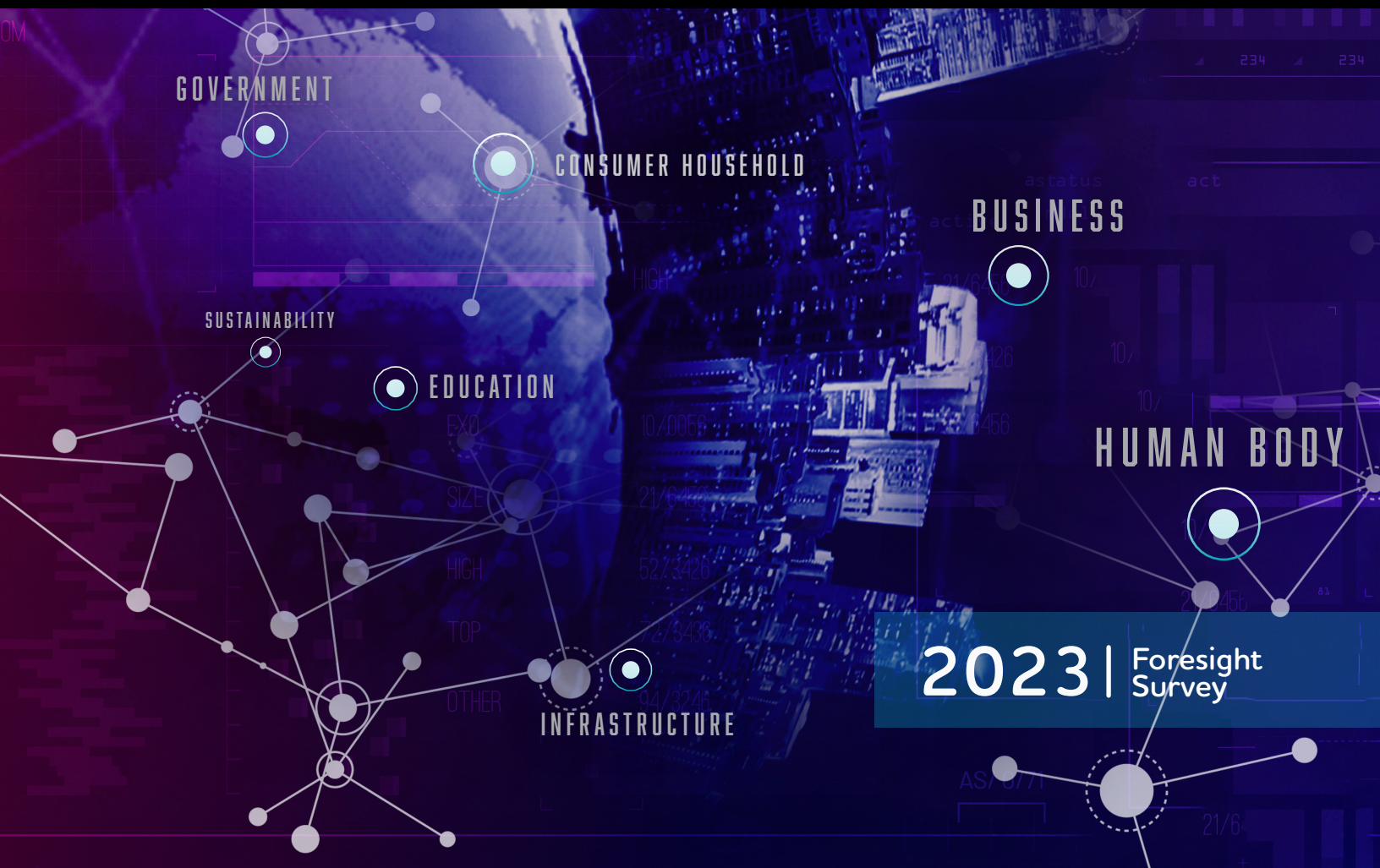
Building on belief

The TCS Digital Twindex

Digital Twins will reshape business and society by 2035



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Digital twins will become commonplace across business and society by

2035

52%

of participants believe broad adoption of digital twins in life sciences and healthcare will happen in the next 3 years

42%

agreed it will take 10 or more years before full digital twins of human bodies become commonplace

Digital twins – virtual replicas of physical objects, processes, or systems that are used to simulate, predict, and improve real-world activities – will revolutionize homes, workplaces, communities, and even healthcare in the coming years, based on findings from TCS Futurists and a network of their peers.

The results from the inaugural **TCS Digital Twindex**, demonstrate the potential for digital twin technology to shape the next decade and beyond:

- Digital twins will become commonplace across business and society by 2035
- Healthcare (52%), mobility (52%) and retail (47%) were selected by respondents as the industries that will adopt digital twins the most quickly, within the next 3 years
- When asked to explain which digital twin use-cases would most impact human life, survey participants pointed to connected, real-time healthcare and efficient energy management
- 52% of participants believe broad adoption of digital twins in life sciences and healthcare will happen in the next 3 years; however, 42% agreed it will take 10 or more years before full digital twins of human bodies become commonplace
- Most surveyed believe that digital twins of smart cities (36%) and households (52%) will come relatively early, within 3-6 years
- Pointing to the benefits of smart cities and smart homes, experts believe digital twins will help people exist more sustainably and with a better standard of living at later ages
- When asked to identify the risks of digital twins, experts overwhelmingly highlighted privacy, cybersecurity, and concerns around data management

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Overview

The Digital Twindex has been prepared by TCS Futurists based on a study conducted using the Delphi technique, which is utilized in foresight to reduce bias and reach consensus around both quantitative and qualitative questions. Participants in the study included scientists, futurists, and subject matter experts from across TCS' networks. They were asked to rate how soon widespread digital twin adoption would occur across industries and society at large and answer open-ended questions around the impact and risk of digital twin technologies.

TCS' Futurists are responsible for engaging with C-suite executives, especially Chief Innovation Officers, and business unit leads to help them understand and prepare for future risks and opportunities. As an emerging technology that is already providing value to organizations, and has the potential to change humanity in the future, digital twins have been a key area of research and investment for TCS.

The Digital Twindex illustrates why digital twins are seeing exponential adoption and interest today. In short, digital twins offer a practical and visionary path forward – in business and daily life.

Findings

Figure 1 | Healthcare, retail, mobility, and sustainability are areas where digital twins can create immense value.

One of the most significant advantages of digital twins is their ability to use data to model future scenarios. This capability has proven crucial in industries such as manufacturing, where digital twins can anticipate machine failures and optimize maintenance schedules, reducing downtime and costs.

Experts predict that these benefits will be democratized across many industries in the coming years, with survey participants pointing to connected, real-time healthcare and efficient energy management as the two use-cases that will most benefit human lives.

In healthcare, digital twins of the human body can help ensure medical procedures are rehearsed and run smoothly, and enable highly personalized treatment. This will be the most difficult feat to accomplish, with surveyed experts believing a digital twin of the full human body is at least 10 years away for the majority of us, given the complexity, variations, and likely regulatory requirements. That said, individual twins of human organs, such as TCS' Heart and Skin BioTwins, already show the potential of future treatments.

Futurists and digital twin experts noted widespread benefits from smart cities arriving within 3-6 years, potentially lowering energy costs and providing more personalized and seamless experiences around transportation, shopping, and other elements of daily life. Indeed, there are already several examples of cities, and even countries, creating their own digital twins. As benefits materialize, digital twins for municipalities will be in even greater demand, causing exponential growth.

A **digital twin** is a virtual replica of a physical object, process, or system that can be used to simulate, predict, and improve real-world activities.

> One of the most significant advantages of digital twins is their ability to use data to model future scenarios.

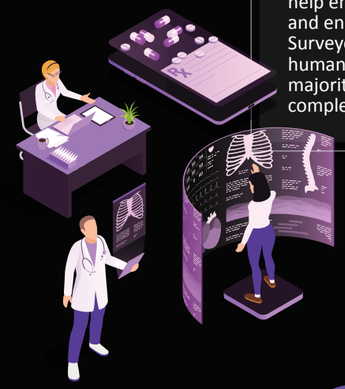
Connected cities will help bring about a new era of retail, with survey participants highlighting common digital twins in the space arriving early, within the next 3 years. Retail businesses will leverage DTOC (Digital Twin of the Customer) to predict spending patterns and preferences. For the consumer, true personalization will be accomplished with the ability to use their own digital twin as a platform to customize shopping experiences.

In the home, where experts also estimate digital twins will become common within 3-6 years, a digital twin could provide energy efficiency, convenience, and comfort, and improve safety conditions. The demographic realities of an aging population, which exists in many countries, will require a real-time form of interactive, non-invasive surveillance such as what digital twins can provide. This will be essential to realizing the promises of a smart home revolution around aging in place.

Digital Twin Foresight Survey

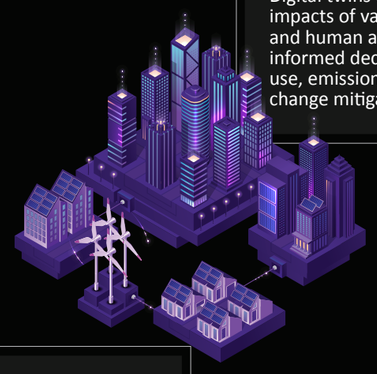
We surveyed Futurists and Industry Experts on Digital Twins' impact over the next decade and beyond. The graphic below illustrates participant input on the timeline of adoption across various industries and functional areas.

Industry Adoption Functional Adoption



HUMAN BODY

In terms of the human body, digital twins can help ensure medical procedures run smoothly and enable highly personalized treatment. Surveyed experts believe a digital twin of the human body is at least a decade away for the majority of us, which makes sense given the complexity and variations involved.

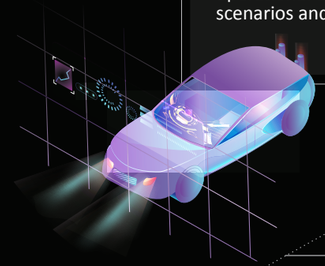


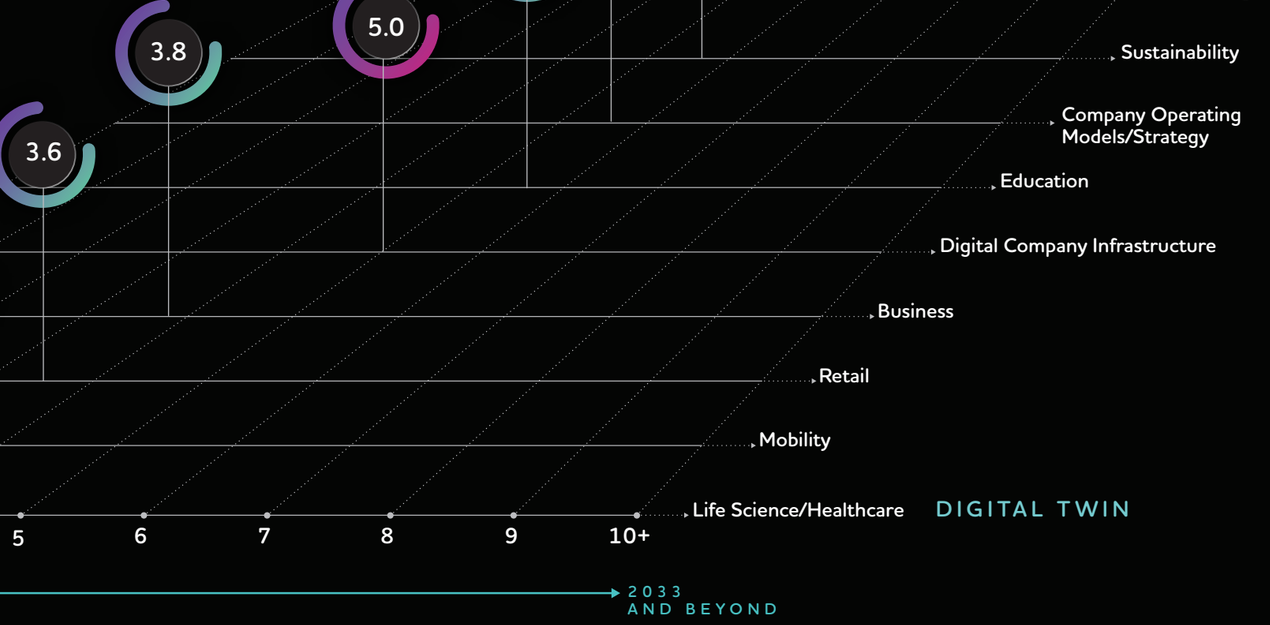
SUSTAINABILITY

Digital twins can model and predict the impacts of various environmental factors and human activities, allowing for more informed decision-making about resource use, emissions reduction, and climate change mitigation strategies.

MOBILITY AND RETAIL

In retail and mobility sectors, digital twins can enhance customer experiences and operational efficiency by simulating various scenarios and optimizing outcomes.





CONSUMER HOUSEHOLDS

In the home, which experts estimate as 3-6 years out, a digital twin could produce energy efficiency and improve safety conditions.

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*The year predictions reflected are based on an average from survey responses.

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ANALYSIS

Adoption:
Saving Lives

Frank Diana
Principal Futurist, TCS

> The capability to rehearse the future will be key for businesses who must navigate an increasing number of challenges in the coming years.

Digital twins will change how we live and work by 2035, with potential to make humanity healthier and more effective at everything we do. In addition to the business benefits, which are already arriving, digital twins within healthcare and life sciences will truly save lives – human and animal.

The progress of digital twins allows us to envision a world in which testing of new technologies, surgical procedures, cosmetics, and drugs for the human body happens entirely in cyberspace. There would never be the need to experiment on an animal again, and at the same time, research and results would happen at scales and speeds exponentially higher than what is possible in the real world.

When it comes to business, digital twin technology will act as a critical enabler for executives that need to rehearse the future. Accurately predicting the future is virtually impossible given the speed and complexity of converging factors. Instead, businesses need to See, Rehearse, and Adapt to likely scenarios, and digital twin technology will dramatically advance the ability to leverage this framework.

Digital Twindex participants also envisioned how digital twins will transform how businesses organize, with many connecting the predictive nature of digital twins to an ability to collaborate with other organizations more closely.

In the coming years, we will see lines between businesses blur as horizontal ecosystems take hold. In this context, successful businesses will be those that have the foresight and agility to treat their organizations as modular entities where capabilities can be leveraged based on need: for instance, agilely working with a specialized startup during a future pandemic to integrate response scenarios and quarantining capacity models.

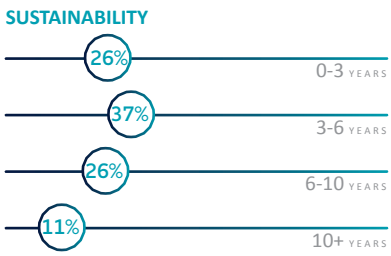
Scenario-planning from digital twins will be essential to achieving these capabilities, and in ensuring a responsible and sustainable approach to business of the future.

Alexandra Whittington
Futurist, TCS

> As access to digital twins is gained, we can assume greater wellness, learning, and civic engagement can be achieved.

Figure 2 | Digital twins in healthcare could significantly impact human lives.

Figure 3 | When it comes to sustainability, digital twins can model and predict the impacts of various environmental factors and human activities.



Optimism:
Sustainable & Equitable Futures

Digital twins are going to help us realize a more sustainable and equitable future than we ever thought possible.

It's clear from responses from a network of futurists and digital twin experts that this technology will soon work in support of people reaching their full potential. The diffusion of digital twin technology to healthcare, education, and government will arrive within six years, according to the study. This signals improvements to quality of life sooner rather than later. As access to digital twins is gained, we can assume greater wellness, learning, and civic engagement can be achieved.

This is evident in the focus group responses to the question, "Which digital twin use-cases will most impact human lives?" Healthcare, sustainability, and basic needs like food and water were common answers, all which cluster around sustaining life at all levels. This is likely due to the immediate and significant impact these areas can have on individual and collective well-being.

As mentioned by several respondents, digital twins in healthcare could significantly impact human lives. They can aid in personalized treatment plans by creating a digital replica of an individual's health profile. This would enable doctors to predict health outcomes, monitor chronic conditions, and optimize treatment strategies. Digital twins can also streamline drug development and clinical trials, potentially leading to faster cures and more effective medicines. A digital twin that encompasses the entire healthcare ecosystem would allow for holistic patient care. It would enable care providers to have a full picture of a patient's health history, lifestyle, and socio-economic factors, leading to more accurate diagnoses and personalized treatments. Furthermore, it could streamline healthcare operations and coordination among different healthcare providers, enhancing overall patient care and reducing costs.

When it comes to sustainability, digital twins can model and predict the impacts of various environmental factors and human activities, allowing for more informed decision-making about resource use, emissions reduction, and climate change mitigation strategies. Additionally, they can help optimize energy use and waste management in various sectors, contributing to a more sustainable future.

The considerable regard for human, planetary, and animal life across these responses tell us that digital twins may enhance the living systems we depend on to survive.

Kevin Benedict
Futurist, TCS

> This is a complex issue that may require a combination of technical and regulatory solutions, such as ensuring that individuals have the right to understand and influence how digital twins impact their lives.

Risk:
Realizing Vulnerabilities

When we asked experts to identify the biggest risks involved with digital twin technology, many pointed to the need to manage risk through governance or regulatory bodies.

The power of digital twins is that they remove uncertainty, helping us see from a distance and act from afar. They can help us have visibility and manage factories, equipment, and operations all around the globe from a central location. Yet these capabilities come with a new set of vulnerabilities and challenges that business and society must solve for.

While digital twins offer numerous benefits, they also raise concerns about privacy and security, as they involve collecting and analyzing large amounts of data. It's crucial for the public to understand what data is used, how it's protected, and the measures in place to ensure privacy. At the same time, businesses need to ensure robust data protection measures are in place and that their use of digital twins complies with relevant regulations.

With the survey participants highlighting the following challenges, it's clear that a focus on ongoing digital transformation and data management will be essential for success with digital twins:

- **Cybersecurity:** Digital twin platforms, like any technology that handles data, are vulnerable to cyber-attacks. If compromised, they could expose sensitive data or cause disruptions to the systems they're modeling. Mitigation strategies should include robust cybersecurity protocols, regular system updates and patches, and continuous monitoring for any suspicious activities. Regulatory bodies should set cybersecurity standards for digital twin technologies and ensure their enforcement.

- **Privacy:** Digital twin platforms often handle sensitive data, which if misused, could infringe on individuals' privacy rights. Regulations should enforce data anonymization and pseudonymization techniques, where necessary, to protect personal data. They should also ensure that digital twin technologies comply with existing data privacy laws, such as GDPR in Europe.

- **Data Quality:** The effectiveness of digital twins is completely dependent on the quality of data received. Poor data quality could lead to inaccurate models and incorrect decisions. This could be mitigated by implementing data validation and cleaning procedures. Regulations could mandate the use of standard data quality measures for digital twin technologies.
- **Lack of Interoperability:** Digital twin data often needs to be shared with a variety of different systems, and a lack of interoperability could limit the overall value of the data. Standards should be developed to ensure that different digital twin technologies can work together seamlessly.

While some of these can be solved through a focus on safeguarding and governing data correctly, other challenges involve ethical dilemmas. As digital twins become more integrated into our lives, there's a risk that they could erode personal decision-making autonomy. This is a complex issue that may require a combination of technical and regulatory solutions, such as ensuring that individuals have the right to understand and influence how digital twins impact their lives.

If the data and algorithms used by digital twins are not transparent, it can lead to mistrust in their results. Regulations should enforce transparency requirements, including disclosing the data sources and algorithms used by digital twins.

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Conclusion

Digital twins are poised to be a major force in the transformation of business and society in the next 10 years. Futurists and experts envision the industries that will be impacted first will be healthcare, retail, and mobility.

As innovation continues, humans stand to benefit in incredible ways from the widespread adoption of digital twins. The world of the 2030s could see every person have a digital twin "live" alongside them, learning and changing in real-time.

The TCS Digital Twindex demonstrates the road to realizing the potential of widespread digital twin adoption, marking each industry's path to transformation, and the benefits, use-cases, and risks that lie ahead.

For More Information on Digital Twins ▶

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Appendix

Survey Questions and Responses

Q1 | When will we see broad adoption of digital twins within Business?

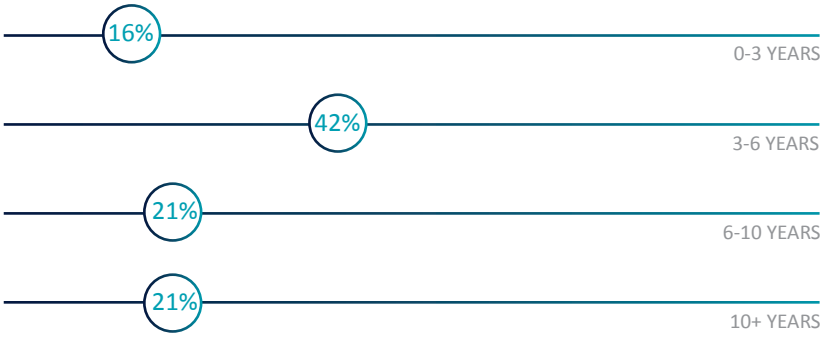
BUSINESS

Q2 | When will we see broad adoption of digital twins within Education?

EDUCATION

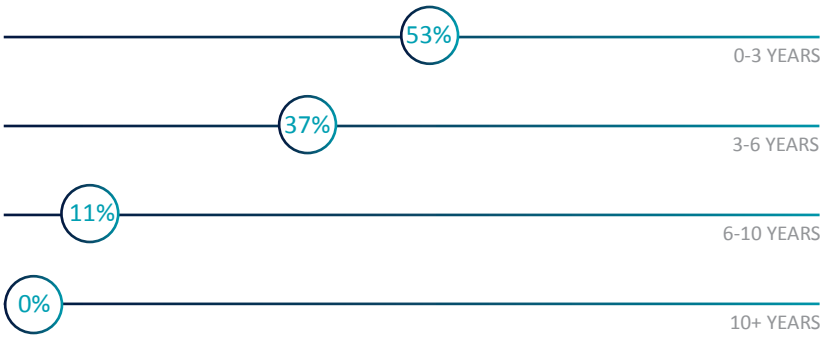
Q3 | When will we see broad adoption of digital twins within Governments?

GOVERNMENTS



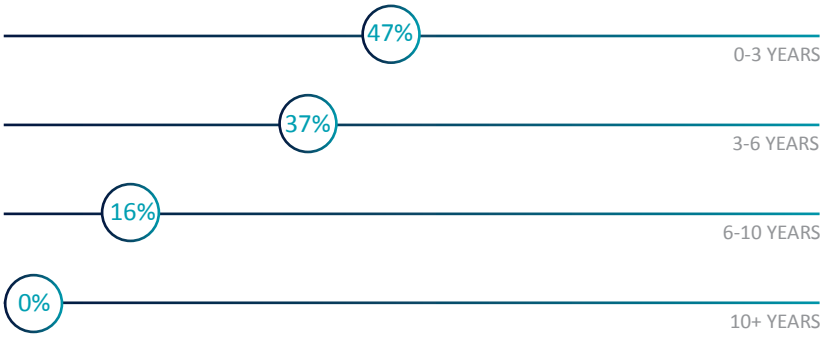
Q4 | When will we see broad adoption of digital twins within Life Sciences / Healthcare?

LIFE SCIENCES / HEALTHCARE



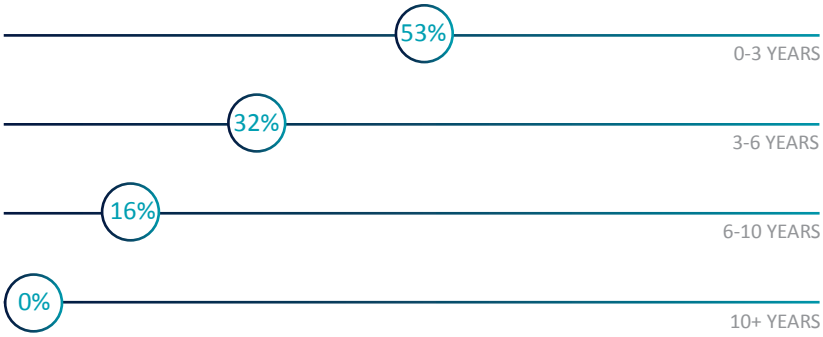
Q5 | When will we see broad adoption of digital twins within Retail?

RETAIL



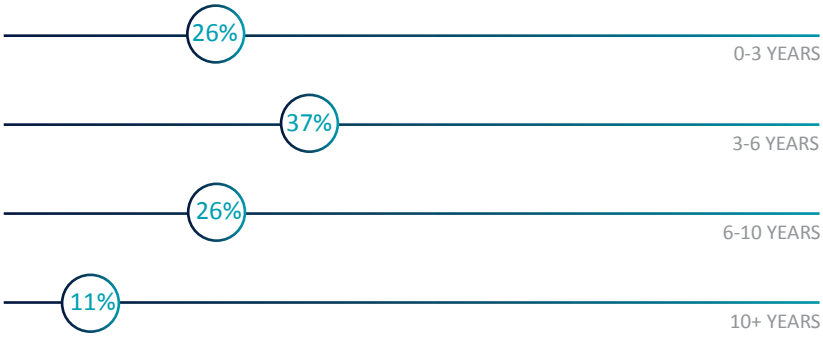
Q6 | When will we see broad adoption of digital twins within Mobility?

MOBILITY



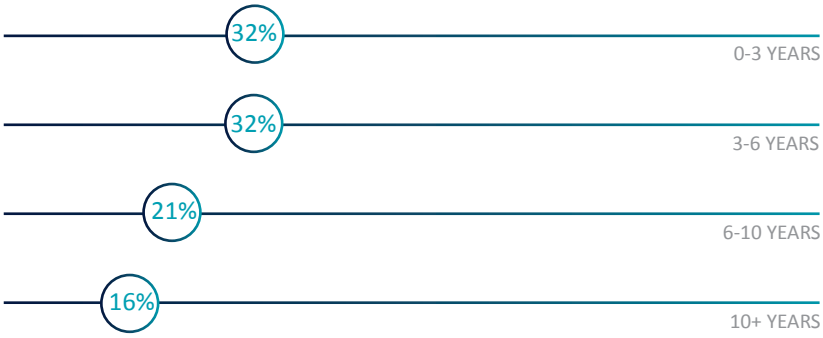
Q7 | When will we see broad adoption of digital twins within Sustainability?

SUSTAINABILITY



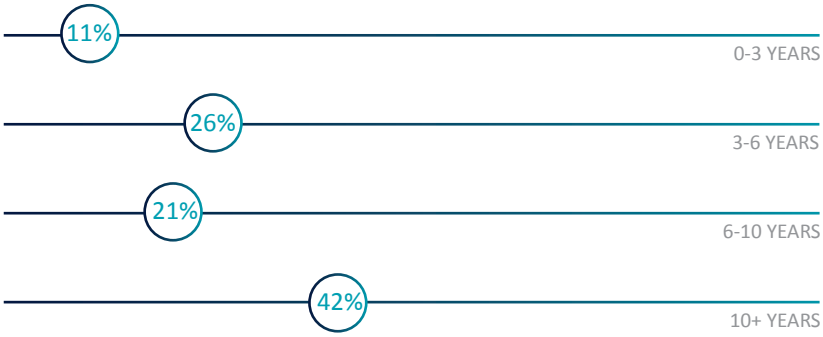
Q8 | When will we see broad adoption of digital twins within Food / Agriculture?

FOOD / AGRICULTURE



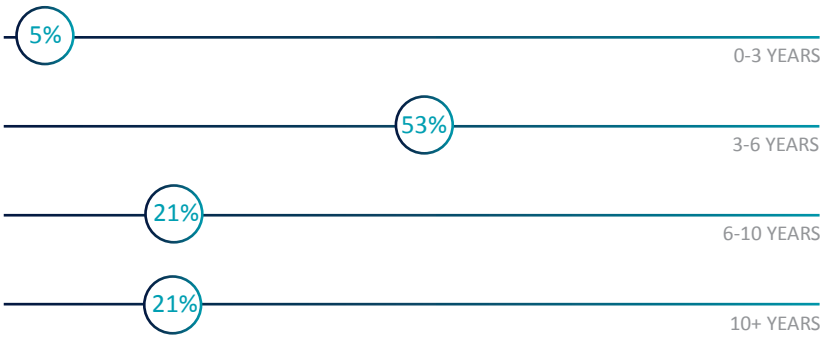
Q9 | When will digital twins of the human body be commonplace?

HUMAN BODY



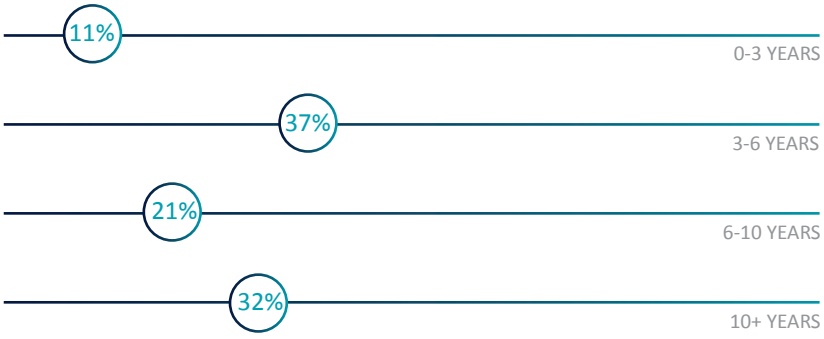
Q10 | When will digital twins of consumer households be commonplace?

CONSUMER HOUSEHOLDS



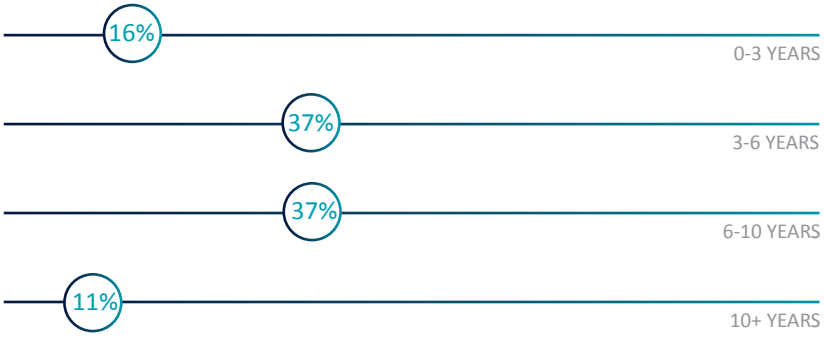
Q11 | When will digital twins of municipal districts / cities be commonplace?

MUNICIPAL DISTRICTS / CITIES



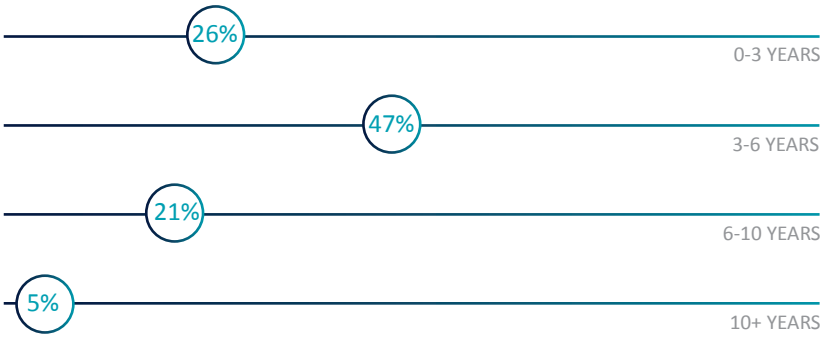
Q12 | When will digital twins of physical company infrastructure (offices, manufacturing plants, warehouses, etc) be commonplace?

PHYSICAL COMPANY INFRASTRUCTURE



Q13 | When will digital twins of digital company infrastructure (databases, applications, software, etc) be commonplace?

DIGITAL COMPANY INFRASTRUCTURE



Q14 | When will digital twins of company operating models / strategy (supply chains, distribution strategy, customer personas) be commonplace?

OPERATING MODELS / STRATEGY