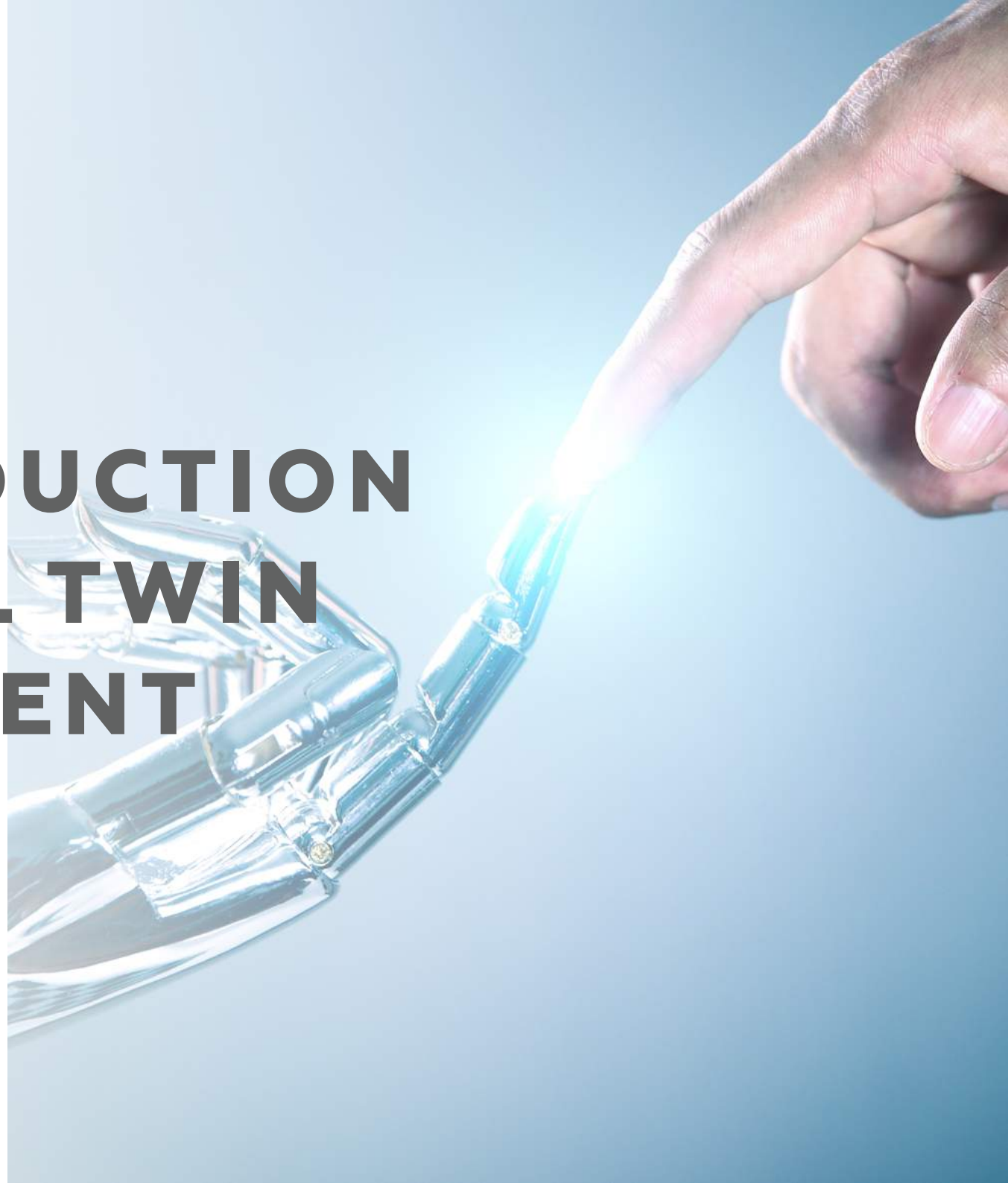




AN INTRODUCTION TO DIGITAL TWIN DEVELOPMENT

WHITE PAPER



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INTRODUCTION

Competition is driving businesses to adopt digital twins. What are they, why are they needed, and how can they be developed?

A digital twin is a special type of simulation model that represents a specific example of something in the present, such as a machine or a business process. It is achieved by combining current data from the subject with its simulation model. The results enhance business insight and performance in manufacturing, transport, supply chain, healthcare, and more, throughout verticals and across industries, but how?

To understand the benefits of a digital twin, it is necessary to understand the possibilities they present. This paper will examine their characteristics and construction, the problems of producing a good digital twin, and, with examples, show their value.

If you are not already developing or working with a digital twin, now is the time. Gartner predicts 'that by 2021, half of large industrial companies will use digital twins, resulting in those organizations gaining a 10% improvement in effectiveness.'¹ While Deloitte states 'Organizations seeking to boost innovation and business performance should explore the transformative insights that digital twins can deliver.'²

Adopting a digital twin is becoming easier. The costs of computation and communication continue to decrease, while model building tools further develop in their abilities. This has helped them become one of Gartner's top 10 strategic technology trends for 2018³.

True to the trend, multiple industries are putting digital twins to work, and examples include factory processes, global supply chains, machine maintenance, and even pharmaceutical research and development.

In each industry, digital twins can have many uses, and present many possibilities for innovation, but it is their use to give real-time insight, enable forecasting, and provide decision support for live operations that is most immediately accessible. With these abilities, companies can be more effective, improve efficiency, and deliver cost savings.

¹ Christy Pettey, "Prepare for the Impact of Digital Twins", Gartner, September 18, 2017, <https://www.gartner.com/smarterwithgartner/prepare-for-the-impact-of-digital-twin>

² Adam Mussomeli, Brian Meeker, Steven Shepley, and David Schatsky, "Expecting Digital Twins", Deloitte, 2018, https://www2.deloitte.com/content/dam/insights/us/articles/3773_Expecting-digital-twins/DI_Expecting-digital-twins.pdf

³ Christy Pettey, "Gartner Identifies the Top 10 Strategic Technology Trends for 2018", Gartner, October 4, 2017, <https://www.gartner.com/en/newsroom/press-releases/2017-10-04-gartner-identifies-the-top-10-strategic-technology-trends-for-2018>

WHAT ARE THE CHARACTERISTICS OF A DIGITAL TWIN?



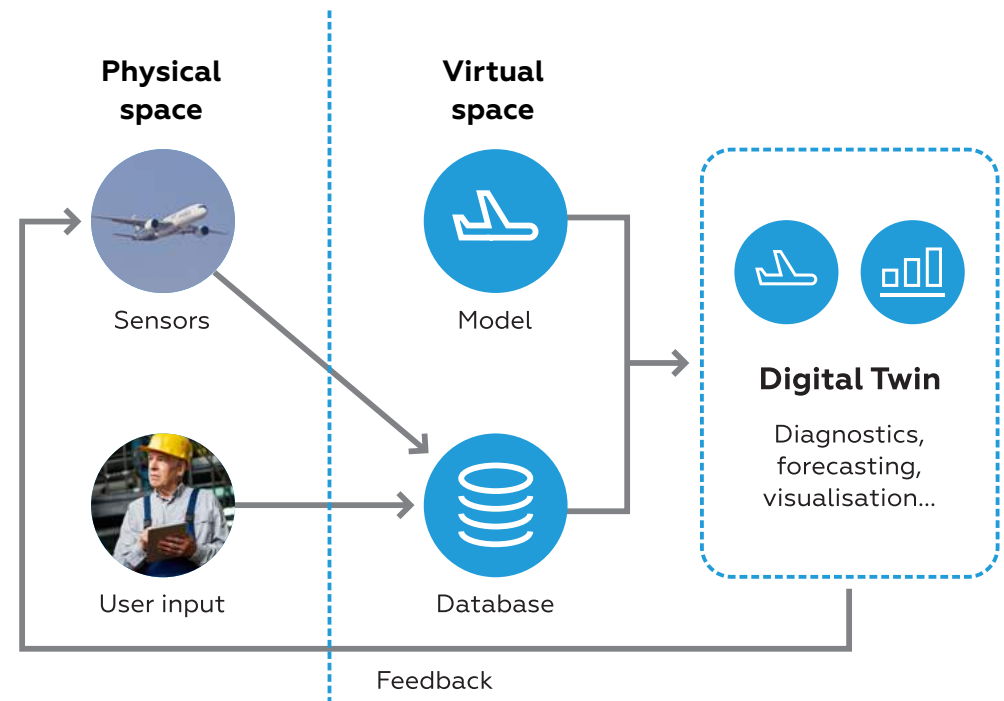
WHAT ARE THE CHARACTERISTICS OF A DIGITAL TWIN?

The specific details of a digital twin will depend on its scale and purpose, but there are two essential characteristics. A digital twin must:

1. **Always represent an existing operational object** – from design proposal to system decommissioning, the digital twin will reflect a specific object.
2. **Represent the object's real-world state** – provide data that describes the present and historical condition of the object or process. This information, e.g. engine temperature and speed, may be from user input or sensors, often IoT (Internet of Things), and should be collected over time for further use.

Combined, these two characteristics create a virtual representation of a real-world system and its status. It is the ability to determine the state of a specific object that sets a digital twin apart from a simple simulation model. The update frequency for the data to represent the real-world state will vary – a turbine's state may be updated regularly and frequently, while that of a supply chain, intermittently and asynchronously. As long as the model corresponds to a uniquely identifiable object, and its state is suitably accurate, it can be considered a twin.

DIGITAL TWINS – AN EXAMPLE



A digital twin for an in-use product, using the example of a plane. The combined data and model provide unique analytics for the real-world object.

When appropriate, a digital twin will directly feed back to the real world and make operational changes itself. This possibility can be developed further when managing a fleet of vehicles or equipment. For instance, historical data from older warehouse picking robots can inform maintenance schedules for the efficient operation of newer units.

With a fleet, or series of machines providing data, predictive analytics can be enhanced, and new insights revealed. This makes digital twins grow in their usefulness as they become more widely deployed. The development of a digital twin does not need to capture everything immediately. It should begin where most practical and, as experience develops and needs arise, expand appropriately. An example of a digital twin deployed at scale is given by General Electric.

General Electric produce turbines with built-in sensors to communicate their status. This information is gathered centrally and combined with information from their operations and maintenance network to produce a digital twin that represents the entire lifecycle of each turbine. From development to operation, and across the supply chain, General Electric has a comprehensive overview. Engineers can extrapolate anomalies from sensor readings and make forecasts using simulation, while managers have detailed analytics of the operational economics. The digital twin captures reality and provides the means for informed decision making. Using the twin, Colin Parris, Vice President for Software Research at GE Global Research, [demonstrates](#)¹ a call from a virtual assistant saving \$12m.

¹ Colin J. Parris, Ph.D., VP of Software Research, GE Global Research Center, "Minds + Machines: Meet A Digital Twin" (video), <https://youtu.be/2dCz3oL2rTw>



DEVELOPMENT CONSIDERATIONS



DEVELOPMENT CONSIDERATIONS

The reduction in computation and model-building costs has certainly helped the development of digital twins, but there are still barriers to their widespread implementation. Important examples include the need for data and for a suitable development environment.



DATA

Data is required to maintain an up-to-date digital twin throughout its operational life. Indeed, a model must be paired with relevant data for it to become a digital twin. A model without situational data is generic. With data, it is unique. The data brings the model alive and delivers its usefulness. Data describing the state of the subject, its environment, and how it operates is essential. Without such data it is impossible to verify the model, and as a result, all diagnostics, forecasting, and experimentation are compromised.

Furthermore, collecting this data just once is rarely enough. It must be timely and in agreement with the real-world system it is representing. This is why digital twins are so closely related to the Internet of Things (IoT), with connected devices reporting operational data to the model for processing and analytics. As the cost of computing and communication continues to fall, the IoT will become increasingly widespread and provide the necessary data flows more easily.



MODELING ENVIRONMENT

Developing a model of a real-world system involves multiple components and can quickly become complex. Models can also expand into multiple realms. For example, supply chain analysis can benefit from modeling warehouse and retail operations. However, modeling these environments may require different approaches, possibly due to the information available, or the nature of the operations – warehouse operations will usually be modeled differently to network-level supply chain operations.

Uniting complex and disparate processes and operations requires a flexible modeling environment, ideally one able to connect differing modeling methods.

Another consideration is software dependency. Minimizing the number of software platforms used for the creation and operation of a digital twin helps streamline support, maintenance, and further development.

The following two case studies demonstrate digital twins that use a single platform to bring together digital models with operational data. These digital twins work on fleets: in the first case, leveraging the big data of a fleet; and in the second, resolving difficulties resulting from the real-world operation of the fleet.

**CASE STUDY:
A DIGITAL
TWIN OF A GAS
TURBINE FLEET**



CASE STUDY: A DIGITAL TWIN OF A GAS TURBINE FLEET

Siemens introduced a new gas turbine for energy production after acquiring the business from Rolls-Royce. The integration of the product into their operations and maintenance created unforeseen challenges and their spreadsheet-based forecasting failed to perform efficiently under the new circumstances. The quantity of data was difficult to manage, and the results were not sufficiently clear to provide the necessary insight for problem identification.

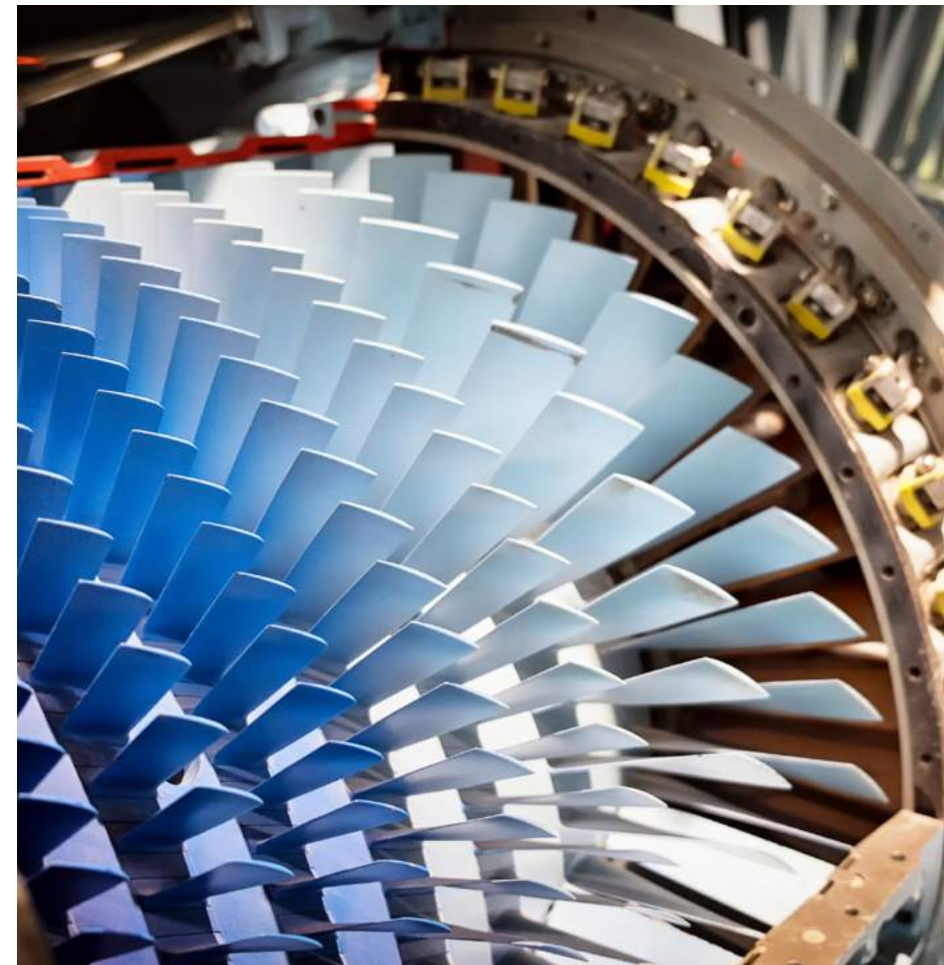
To address the problem, Siemens worked with decisionLabs. The solution was an AnyLogic based digital twin. As a single, unifying platform, it enabled the use of sophisticated simulation and data analytics to model the fleet operations of Siemens gas turbines, including:

- Customer operations
- Maintenance facility operations
- Engine characteristics
- Supply chain and logistics

The key benefits of the ATOM digital twin come from its operation across the whole fleet of Siemens aero-derivative gas turbines where it enables:

- System KPI forecasting
- Operations visualization for fleet and maintenance facilities
- Bottleneck identification and costing
- What-if scenario exploration to inform investment decision-making

[Read the full case study>>](#)



**CASE STUDY:
RAIL FLEET
AND NETWORK
OPTIMIZATION**



CASE STUDY: RAIL FLEET AND NETWORK OPTIMIZATION

The EU OPTIMSED project aims to develop methods and tools for highly optimized and reactive planning across a variety of industrial sectors. Key to the project is modeling and simulation based on real data from smart sensors and pro-active human-machine interfaces – in essence, industrial digital twins.

Working as part of this project, Alstom and Simplan developed a decision support system for train fleet management that would enable system performance understanding and allow change evaluation. Alstom is a world leader in integrated rail systems and Simplan are automotive and logistics consultants, specializing in optimization.

Train maintenance scheduling on the busy and constrained West Coast Main Line in the United Kingdom was identified as an area optimization could help. Trains serviced too early lose money, and those serviced too late risk failure. Changes to scheduling have complex knock-on effects.

Operational realities meant that predicting the location of trains more than a few days ahead quickly became inaccurate. So, despite the schedules, a simple simulation model would not help. To provide usable forecasting, operational updates needed to be included, which meant a digital twin was required.



West Coast Mainline rail network and maintenance depots.



A solution was developed that considered:

- the fleet
- depots and stations
- maintenance regimes
- diagrams (train timetables)

AnyLogic enabled the developers to use multiple modeling methods to capture the railway network and operations, handle different data input formats, and integrate GIS mapping. Being Java-based, it also allowed the developers to create custom Java extensions and a freely distributable standalone application. The result was a digital twin that supports process design decisions in train fleet management.

The solution allows users to understand operations and rail network performance, and to look for optimum solutions under given constraints. As such, trains can be serviced cost effectively by comparing scenarios and evaluating impact factors. Additionally, a visual component helps increase comprehension.

The digital twin has proven useful in many areas: when formulating bids and tenders, for evaluating network designs, implementing optimization, and in end-of-life anticipation and evaluation. Overall, investing in a digital twin benefitted multiple areas of their business.

[Read the full case study>>](#)

MODEL AND DATA MANAGEMENT



MODEL AND DATA MANAGEMENT



MANAGING DATA

As we have seen, digital twins require data. How can this data be provided? Different projects may require different data interaction approaches.

A digital twin development tool that can easily handle data helps simplify its creation. A tool that includes a database can be useful during the early stages of development because developers have less complexity and fewer software interactions to consider. Indeed, given the right scenario, a powerful internal database can be used throughout the life of a digital twin, reducing dependencies and simplifying support.

It is also important to recognize the external data formats and query standards the digital twin will have to work with. To allow easier development and scaling, choose a tool that provides native access to the widest possible range of data management systems – a good digital twin will integrate with other databases or parts of an organization's IT infrastructure as they are developed and deployed.

Feedback tells us that developers use AnyLogic's built-in database when creating the first instances of a digital twin and import data as needed. Then, after the twin is defined, it is easy to migrate to direct access.



THE MODEL

Digital twins are, in a large part, simulations – they must represent the real world in some form – and a capable modeling environment is crucial. However, when considering a digital twin platform, attention should go beyond the ability to create a good model. Developers should consider information flows and visualization as well.

Developing a digital twin requires capturing the necessary real-world complexities, and this often demands more than one modeling method. A multimethod modeling environment can simplify development by providing a single tool to accurately capture all the required details. The speed of deployment and the digital twin's lifetime support will also benefit from using a single tool.

The following case study illustrates how even a narrowly focused digital twin requires a robust development platform for modeling and data handling.

**CASE STUDY:
A DIGITAL
TWIN OF
A PRODUCTION
LINE**



CASE STUDY: A DIGITAL TWIN OF A PRODUCTION LINE

CNH Industrial is one of the world's largest capital goods companies. It wanted to exploit the benefits of Industry 4.0 and was considering the introduction of digital twin capabilities on its commercial vehicle production lines.

Failure on a production line leads to costs. One survey estimated an average of \$22k dollars per minute in the automotive industry, so, the economic impact of improved maintenance processes on a production line is potentially significant.

Working with Fair Dynamics consultants, CNH Industrial identified production line maintenance processes as an area to test the use of digital twins. The result was a prototype for helping make informed maintenance decisions. Opposed to a simulation-only solution, that would simply identify the bottlenecks and constraints, a digital twin would work with data from the real production line to precisely manage maintenance as needed.

Fair Dynamics proposed the reproduction of a single manufacturing line with the capture of key performance and financial indicators to identify the potential added value from investing in new maintenance policies, such as predictive maintenance. The project focused on a production line dedicated to the assembly and welding of van bodies. The main buffers and stations on the line were modeled, including the most critical robots.



The project used AnyLogic and brought together sensor data, machine learning techniques, and agent-based modeling to provide a 'Control Tower' prototype that could:

- Test different maintenance policies
- Test policy resilience when applied to different production plans
- Apply predictive models to determine the remaining useful life of components

By combining a simulation model with production line data, CNH now has a detailed and comprehensive tool for establishing efficient production line operations. It has highlighted the potential benefits of digital twins, as well as the importance of data, both historical and live, and the need to evaluate the economic impact of any changes.

[Read the full case study>>](#)

CONCLUSION

Digital twins are significantly more accessible than before, and their careful use can cut costs and drive profitability. They are already being deployed in a wide variety of industries, and companies who fail to take advantage are at risk of being left behind.

A powerful and flexible simulation environment is key to the successful development of a digital twin. It is necessary for a digital twin to be able to interact with a variety of other software systems, data sources, and users. Furthermore, the scope and scale necessary to model whole real-world objects, operations, and processes through their entire lifecycles means complexity must be easily manageable.

AnyLogic is already in use in multiple fields of business, successfully delivering the advantages digital twins offer. Its simulation modeling environment is ideal for quick development without compromise – as demonstrated by world leading organizations. If you want to bring the benefits of a digital twin to your business, begin with AnyLogic today.



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CONTACTS

THE ANYLOGIC COMPANY

info@anylogic.com

[Contact your local office >>](#)