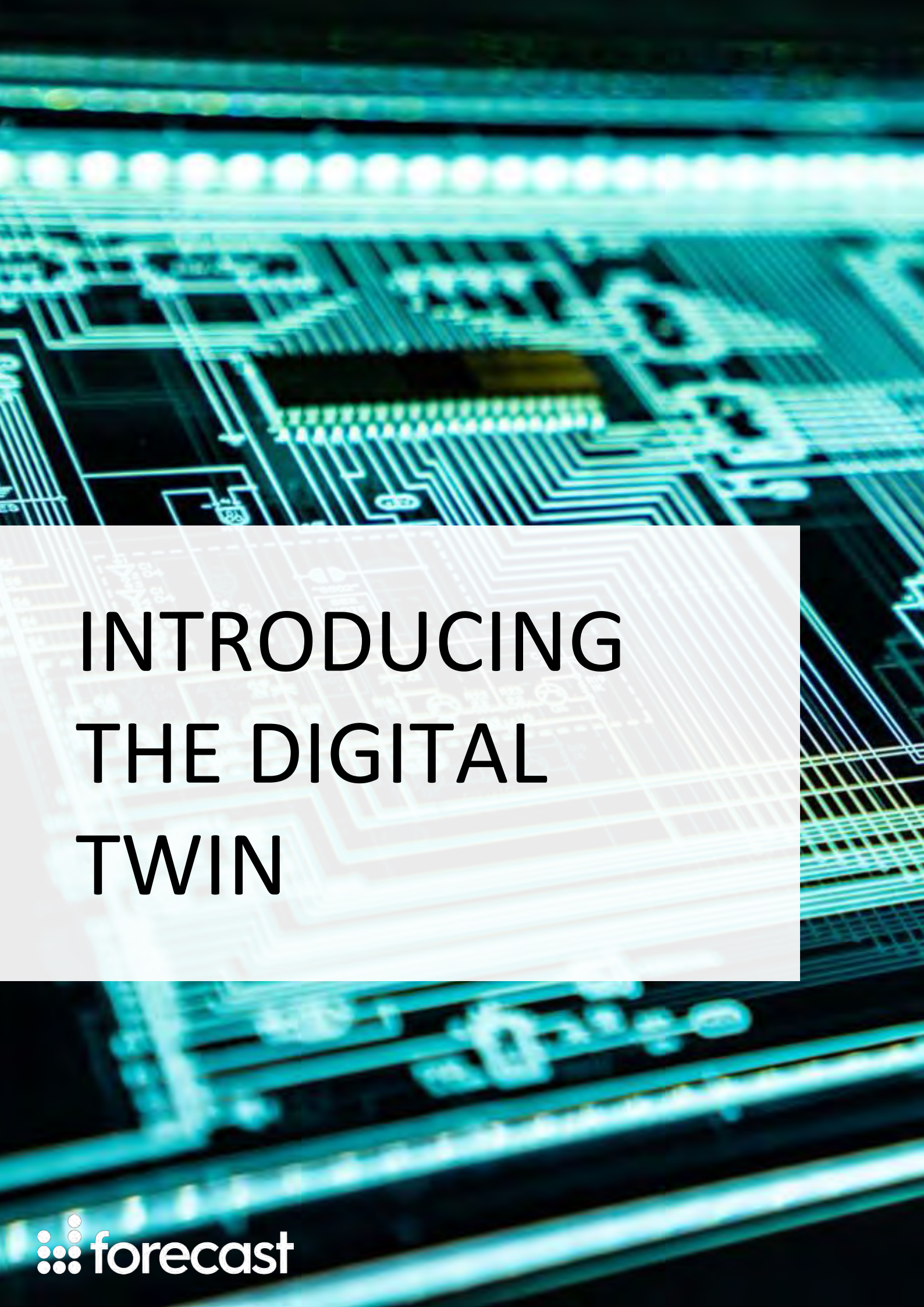


INTRODUCING THE DIGITAL TWIN

forecast

APOLLO 13: A Successful Failure

On April 11, 1970, Apollo 13 launched from Kennedy Space Centre. The mission was to be the third lunar landing program. The launch was successful, but the mission was not - about 56 hours into the mission and 330,000 km from earth, the oxygen tank of the service module exploded.

“Houston, we’ve had a problem.”

The explosion caused the loss of oxygen, water, and fuel cells for the space vehicle. With only 15 minutes of power remaining in the command module, the crew shutdown the computers and other equipment to save power for re-entry.

Back at the Kennedy Space Centre, thousands of engineers were working tirelessly to develop a solution that would bring the astronauts back to earth safely. With the data reported by the Apollo 13 crew, engineers and backup astronauts used an Apollo 13 simulator to replicate the conditions of the damaged space vehicle. Engineers on the ground tried different **What-If** combinations to develop a new feasible re-entry program.

The crew of Apollo 13 successfully returned to earth on 17 April 1970. NASA learnt a lot from the mission and named the mission a ‘Successful Failure’. However, without many failures in the simulator, that chance of success would be close to zero.

The **What-If** Moments of Business

The daily operation of business may not face as catastrophic moments as Apollo 13 experienced, but a failure to make an informed response to an unplanned event can have the potential to cause significant adverse impacts to the operation of the business:

- What-If there is a spike in demand for your product? How long will it take to restock? How fast can you make the shipment?
- What-If there is a weather event that will affect your supply chain? How soon can you switch the manufacturer to the unaffected region?
- What-If the flight schedule changes and the passenger traffic exceeds the designed capacity of an airport?
- What-If there is a workforce shortage? Can the business overcome it by adjusting the shift rosters?
- What-If there is a major event in the city centre? What is the impact to the road network? What is the best diversion plan?
- What-If your Formula1 racing rival pits to change tires, should you pit now or stay out (you have 10 seconds to make a call)? What would be the racing outcome?

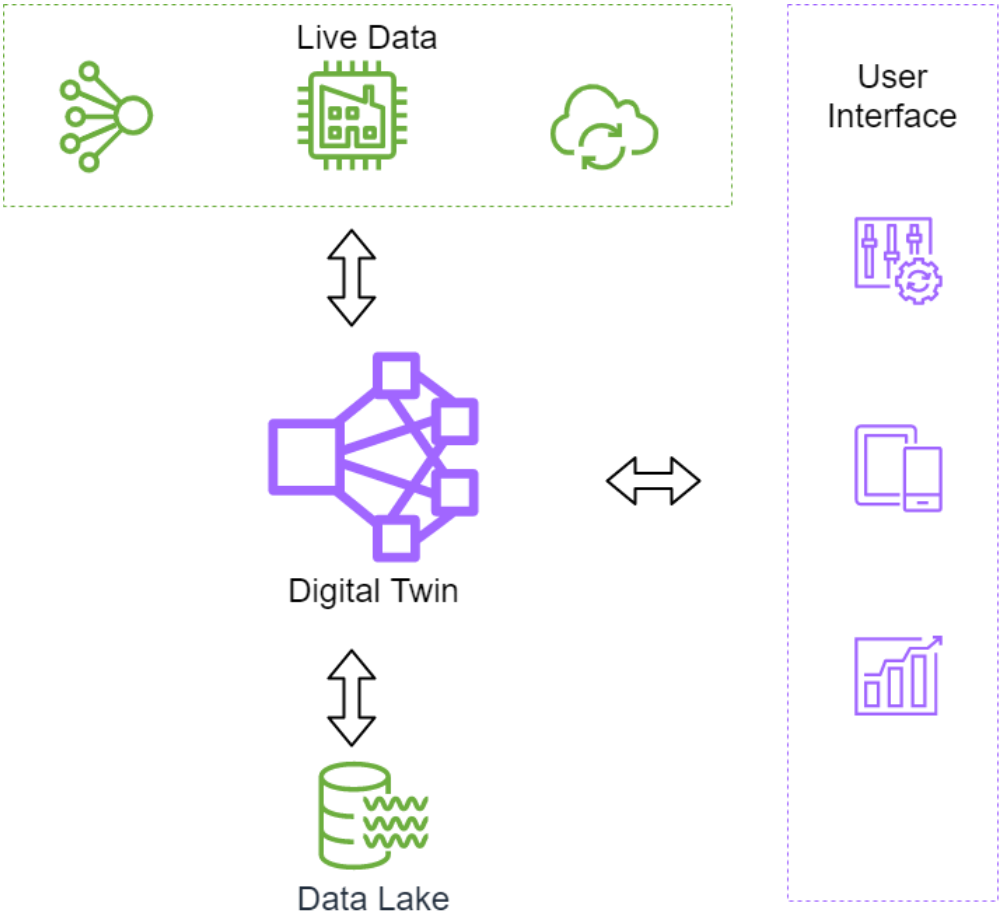
You can name many more What-If moments for your business. The consequences of making incorrect decisions in these situations could be significant. What if there was a Digital Twin that served as the sandbox for your business decisions so you can choose the best approach with confidence?

What is a Digital Twin?

Like the Apollo 13 simulator, a Digital Twin is a software simulator of a business or process. The key difference is that with modern technology Digital Twin models are available to any business, not just those with the budget and resources of NASA.

A Digital Twin connects to operational data sources and integrates with business logic to simulate the activity in your business and allows you to analyse the results in the short, medium and long term.

The diagram below illustrates the essential building blocks of digital twin:



At its core, a Digital Twin is driven by live and/or historic data. You may be familiar with the concept of big data which can be summarized as the '3Vs':

- Volume,
- Velocity, and
- Variety.

The amount and variety of data involved will affect the accuracy and effectiveness of the Digital Twin. Historic data, marketing data, social media data, demographic data, transaction data, shipment data, GPS data, IoT data, sensor data, weather data, news data … all the data relevant to the business operation should be collected and harnessed.

There is nothing mysterious about the Digital Twin itself – it is a software entity that replicates the operating logic of your business. It takes the live and historic data and produces a new dataset to simulate or clone the operations of the business.

The implementation of Digital Twin should be designed to mimic, or clone, the operation of business. Depending on the structure and the nature of the business, the technology approach can take many forms. One can choose to use advanced AI methods such as neural networks, or logical programming to implement the core of Digital Twin.

The User Interface (UI) is another essential component of Digital Twin. UI provides a user-friendly interface to operate the Digital Twin which includes parameter setup, simulation control, results analysis, business intelligence visualisation, etc.

In summary, a Digital Twin utilises software technology to build a virtual business that connects to the real world. It could be too risky or time consuming to observe the impact of a reaction to a **What-If** event in the real environment, so the Digital Twin allows us to conduct multiple trial & error experiments very quickly with no risk to your actual business operations.

Digital Twin Use Cases

The concept of Digital Twin can be applied to different types of businesses and operations, big or small.

Space Mission - with the data acquired from the sensors mounted on the space vehicles, NASA now uses Digital Twins to simulate the operation of space vehicles in the mission. They can also use the Digital Twin to 'Clone' the environment of planet such as Mars to explore the next generation of space vehicles.

F1 Racing – without being physically present at the racetrack, the engineering team can simulate the race by using a Digital Twin and experiment with different strategies to improve the team's performance.

Advanced Traffic Control – with the IoT devices deployed in the city and by connecting to weather data, event calendar data, and traffic information, Digital Twins can help to develop optimised traffic diversion plans.

Logistics Optimisation – with the IoT devices in factories and sensors mounted in the containers and trucks, a Digital Twin can help routing and rerouting the logistics journey adaptively.

Property Management – Digital Twins can simulate the lifetime of hardware installed in the properties, predict failures, optimise HVAC operations, and optimise maintenance without physically visiting geographically dispersed assets to conduct inspections.

Hotel Management – Digital Twins can simulate the room supply consumption rate; estimate guest arrival times; optimise room cleaning activity and predict booking rates enabling adaptive pricing policies.

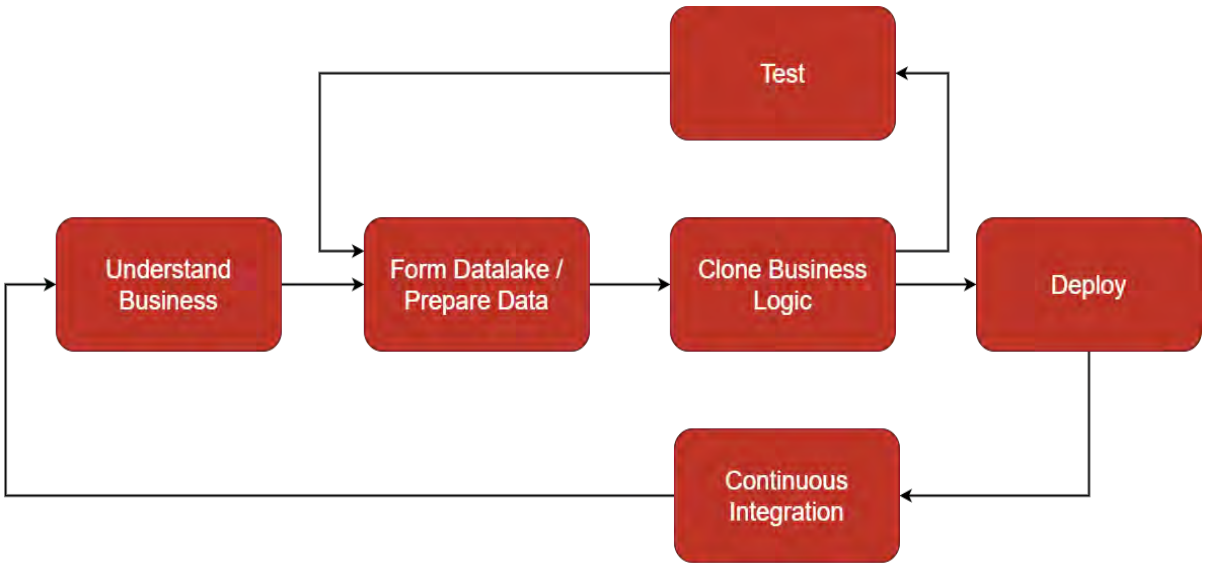
How to build a Digital Twin

The process of building Digital Twin can be characterized as **highly customised** and **highly dynamic**.

There is no single business that is identical to another, so a Digital Twin can not simply be purchased off the shelf and applied to all businesses. In the heart of Digital Twin, the business logic of each component will need to be reproduced to match the operation of the business in the real world.

Businesses consistently reform and evolve which requires dynamic adjustments of the business strategy and structure to be reflected in the Digital Twin. While certain changes can be made via settings adjustments, more fundamental changes such as business restructure will need parts of the Digital Twin logic to be rebuilt.

The diagram below illustrates the process of building Digital Twin.



The journey starts with an understanding of the business. The process helps to identify:

- the key stakeholders of the business,
- available data,
- operation flow,
- collaboration dependencies.

With a solid understanding of the business, the data must then be organised by building a data lake or data infrastructure which can ingest, store, transform and process data required by the Digital Twin.

The next step is to implement the software that clones core business logic. Depending on the needs of business, the fidelity of the clone could be very granular or relatively abstract.

The process can be iterated within a cycle of testing and reimplementing until the performance of the Digital Twin meets the design expectations.

Deployed Digital Twins may be subject to change via the process of continuous integration to reflect changes in the business structure or business strategy.

Due to the highly customised and highly dynamic nature of a digital twin, Forecast proposes to use the 3D design principle of Digital Twins, that is

- **Decentralised**: there should be no single decision-making point of operating flow. The software components of Digital Twin should be able to evolve independently.

- **Decoupled**: the business logic, data and runtime parameters should be separated.

- **Distributed**: while the storage and processing of the Digital Twin could be distributed across multiple computing resources, the behaviour of the Digital Twin should be consistent, like a single software entity.

Airport Operations Digital Twin

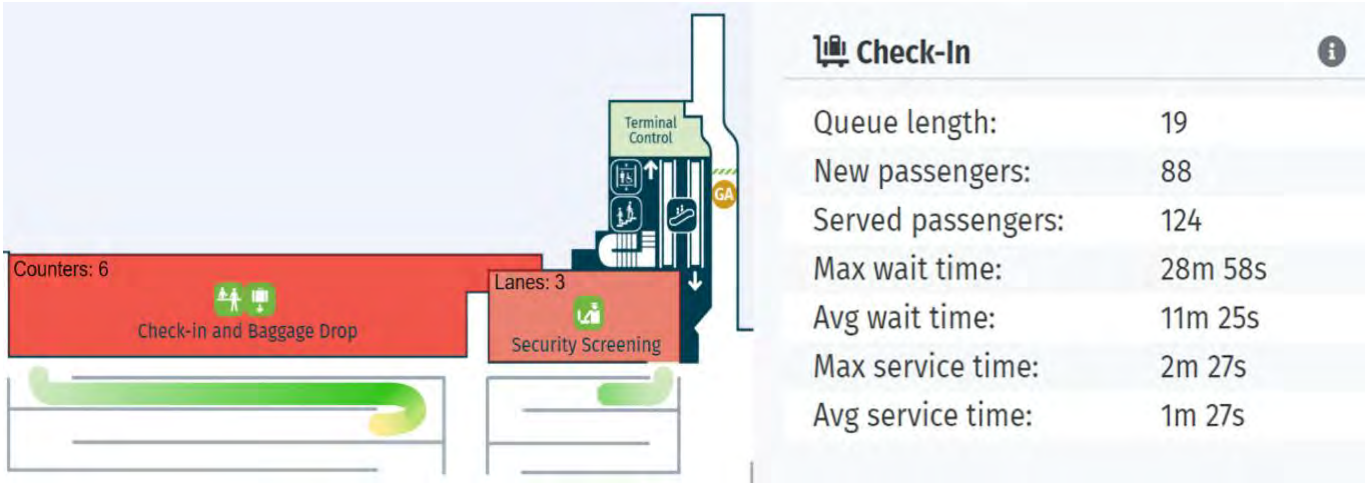
Forecast recently worked with one of Australia's leading airport operators to simulate passenger flows through a terminal using a Digital Twin. Due to the rapidly changing nature of an airport environment, they had a need to understand the impact to their operations when demand changed (e.g., COVID disruptions, or a flight schedule change) as well as cost/benefit trade-offs of changes in resourcing costs to reduce queue lengths and wait times.

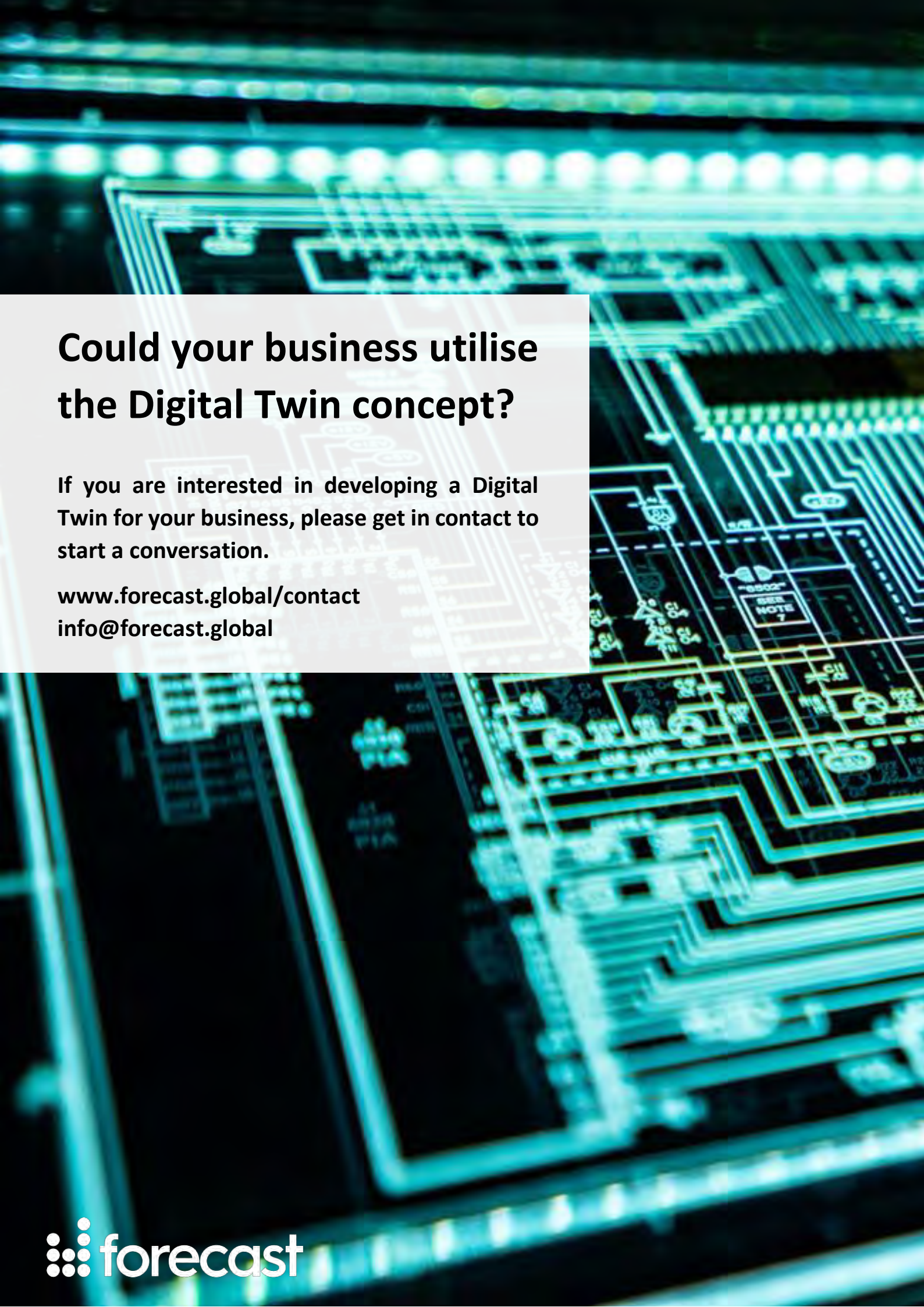
Forecast first conducted a series of workshops at the airport with various stakeholders to observe airport operations and the passenger journey through the terminal. The workshop sessions gave Forecast a chance to understand the business and the operating environment. Through the workshop, Forecast identified the key business flow and key data sources required for the proposed Digital Twin.

Forecast took the approach of building Minimum Variable Product (MVP) to verify the concept. The building of the MVP leveraged serverless computing technology and it was developed and delivered in less than 8 weeks.

The Digital Twin MVP has the capability to simulate 15 months of operations, processing over 1.5 million passengers, and generating 1.7GB operational data … **all within 70 seconds!**

The image below shows an extract of the Digital Twin user interface showing the check-in and baggage drop at a point in time.





Could your business utilise the Digital Twin concept?

If you are interested in developing a Digital Twin for your business, please get in contact to start a conversation.

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