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LEADING ASSET MANAGEMENT

# UNDERSTANDING DIGITAL TWINS

A guide to Digital Twin concepts and good practice for asset-intensive organisations

# GUIDE OBJECTIVES

**Discuss** how the Digital Twin concept relates to asset-intensive organisations;

**Understand** how Digital Twins can improve decision making;

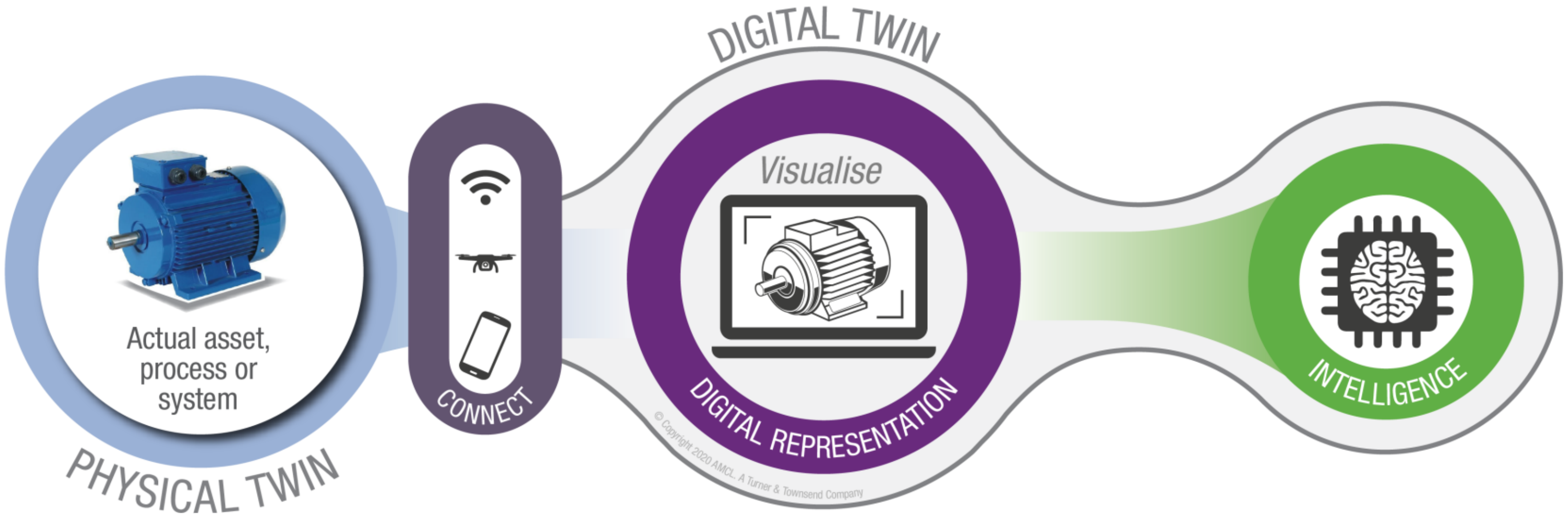
**Demonstrate** Digital Twin use cases;

**Explain** potential technology footprints; and

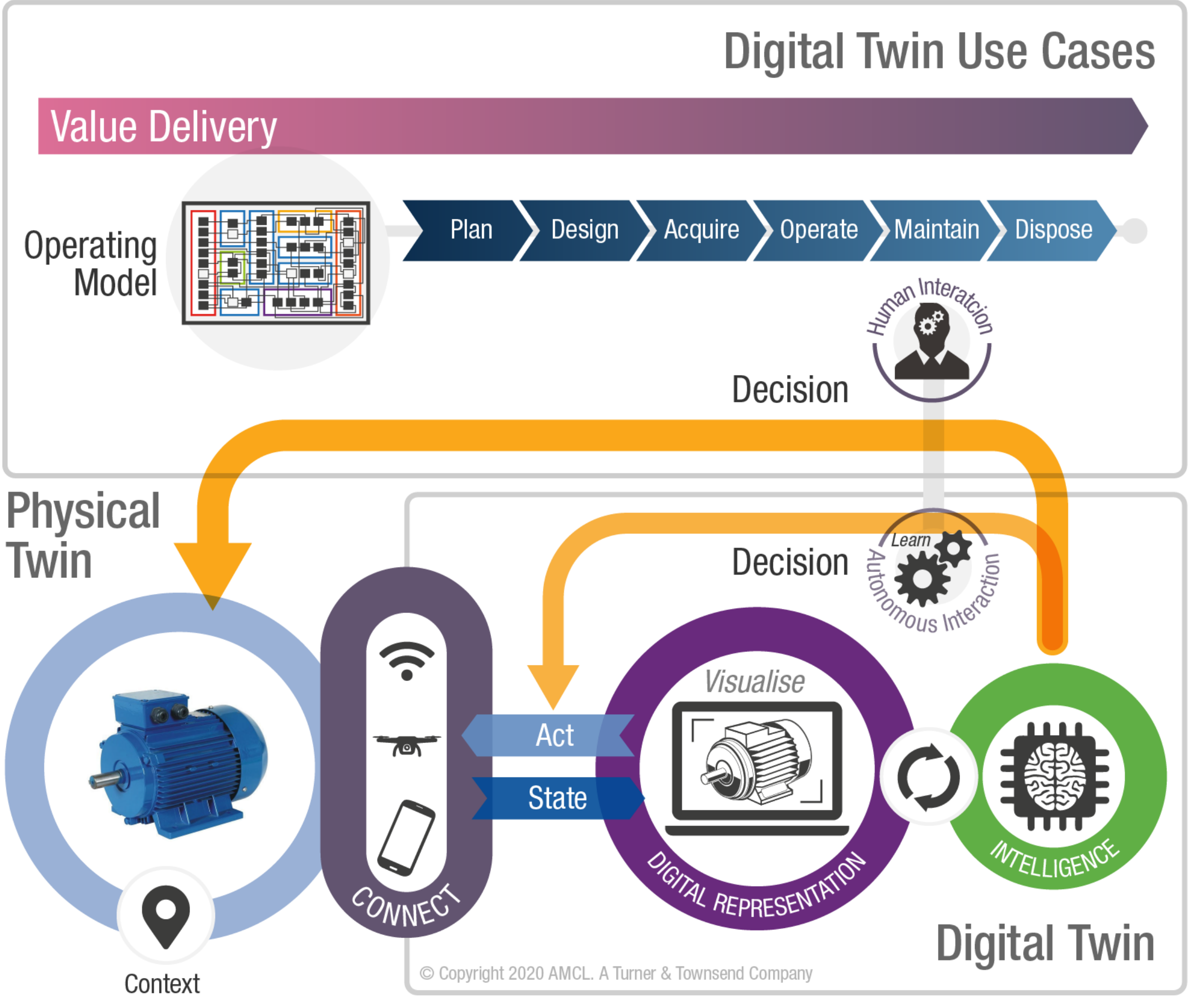
**Recognise** success factors for Digital Twin implementation.

# DIGITAL TWIN DEFINITION

- A **Digital Twin** combines data and technology to provide a digital representation of a **potential** or **actual** asset, process or system. The Digital Twin's functionality can be specified to **understand, control and optimise** the performance of the **Physical Twin**.
- The Digital Twin connects to the Physical Twin through the collection/collation of data (including sensor connections). **Intelligence** can be applied to support both human and autonomous decision making to change the **asset's design and behaviour**.



# WHAT IS A DIGITAL TWIN?



# WHAT IS A DIGITAL TWIN?

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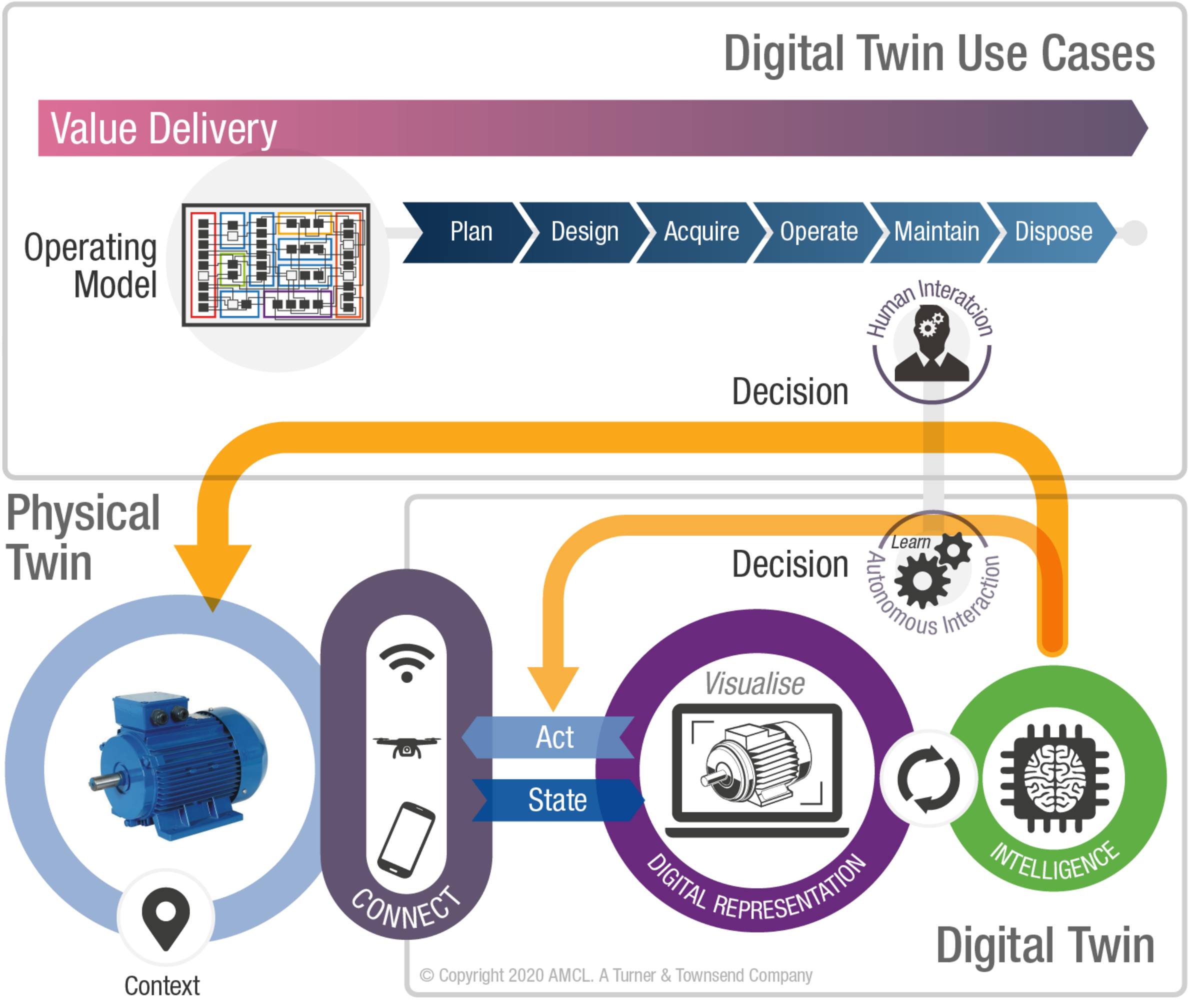
Decisions to act on the Physical Twin can be supported through data **visualisation** for **human** decision making or via advanced **autonomous** interaction

1

A **Physical Twin** is the actual asset, process or system that delivers value within its operating context

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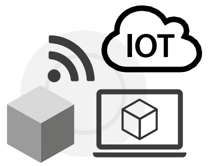
The **purpose** of a Digital Twin is to increase the **effectiveness of decision making** within an organisation's Operating Model

3

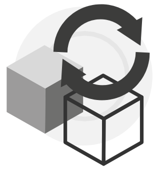
The Digital Twin combines data and technology to:

- **Connect** to the Physical Twin to capture its state, environment or to interact
- Provide a **digital representation** of the Physical Twin
- Apply **intelligence** to the digital representation of the Physical Twin

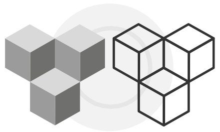
# DIGITAL TWIN MARKET OBSERVATIONS



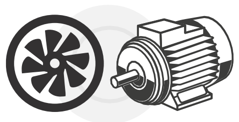

Digital Twin joins other concepts such as Artificial Intelligence, Internet of Things (IoT), Big Data and Augmented Reality in providing the potential to support an organisation's Digital Transformation. To realise the full benefits of a Digital Twin an organisation may require a combination of these emerging technologies. These technologies remain in the early stages of adoption and carry inherent risk to support 'Digitalisation' – the process of moving to a digital centric organisation.



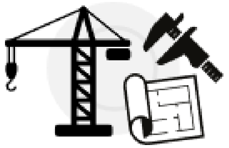
The fundamentals of a Digital Twin approach are nothing new. Operational Technologies, Product Lifecycle Management, simulation and modelling techniques have been in use for decades to visualise, analyse and control asset systems. What is changing is the scale of technology available across asset types and asset systems, with IoT sensors and 3D models readily available from manufacturers and construction partners. Government initiatives around SMART Cities and National Digital Twins are also encouraging adoption. International standards on data and integration protocols reduce risk.



At the heart of the Digital Twin concept is the accurate representation of the physical asset, process or system. However, lower-maturity organisations are still struggling to maintain a good-quality tabular data asset register in traditional IT Systems.

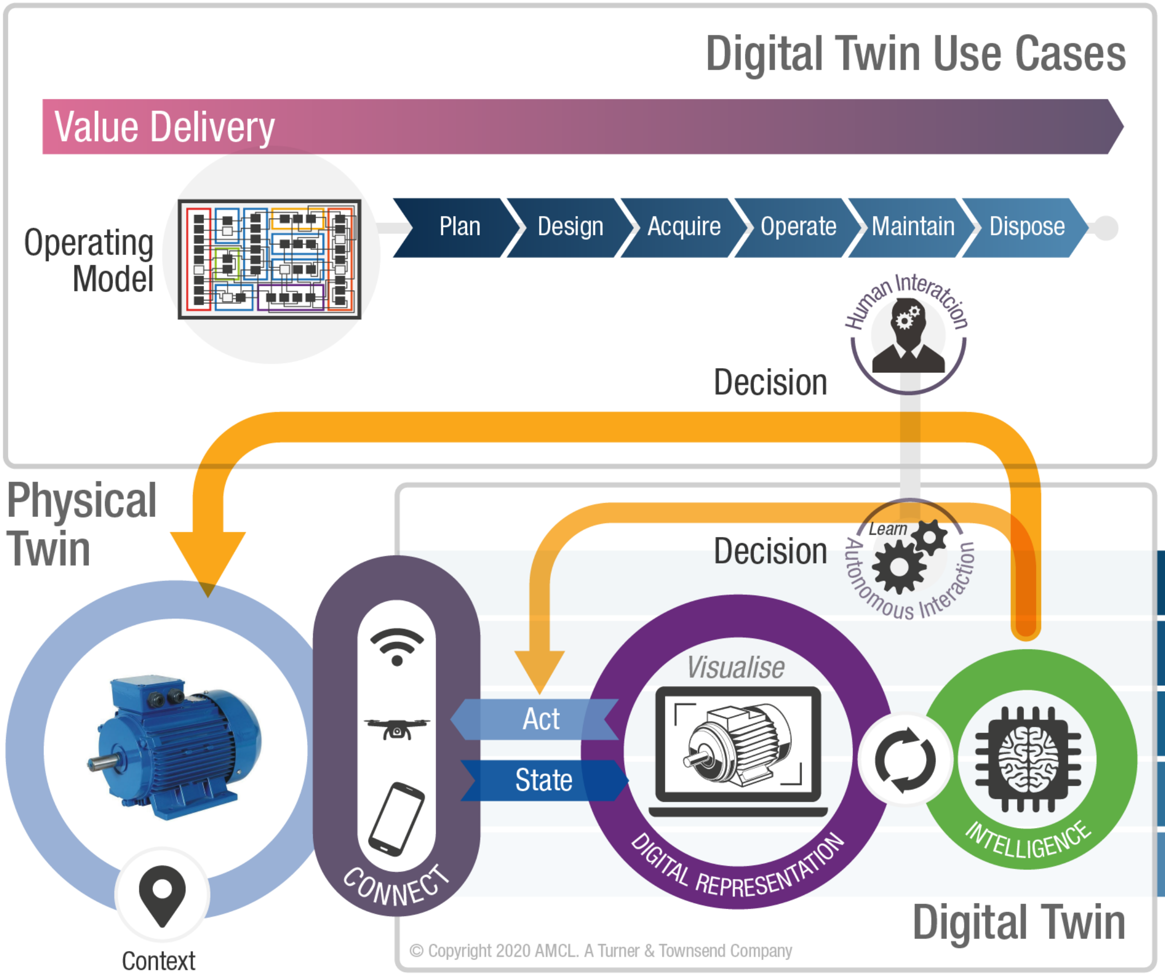


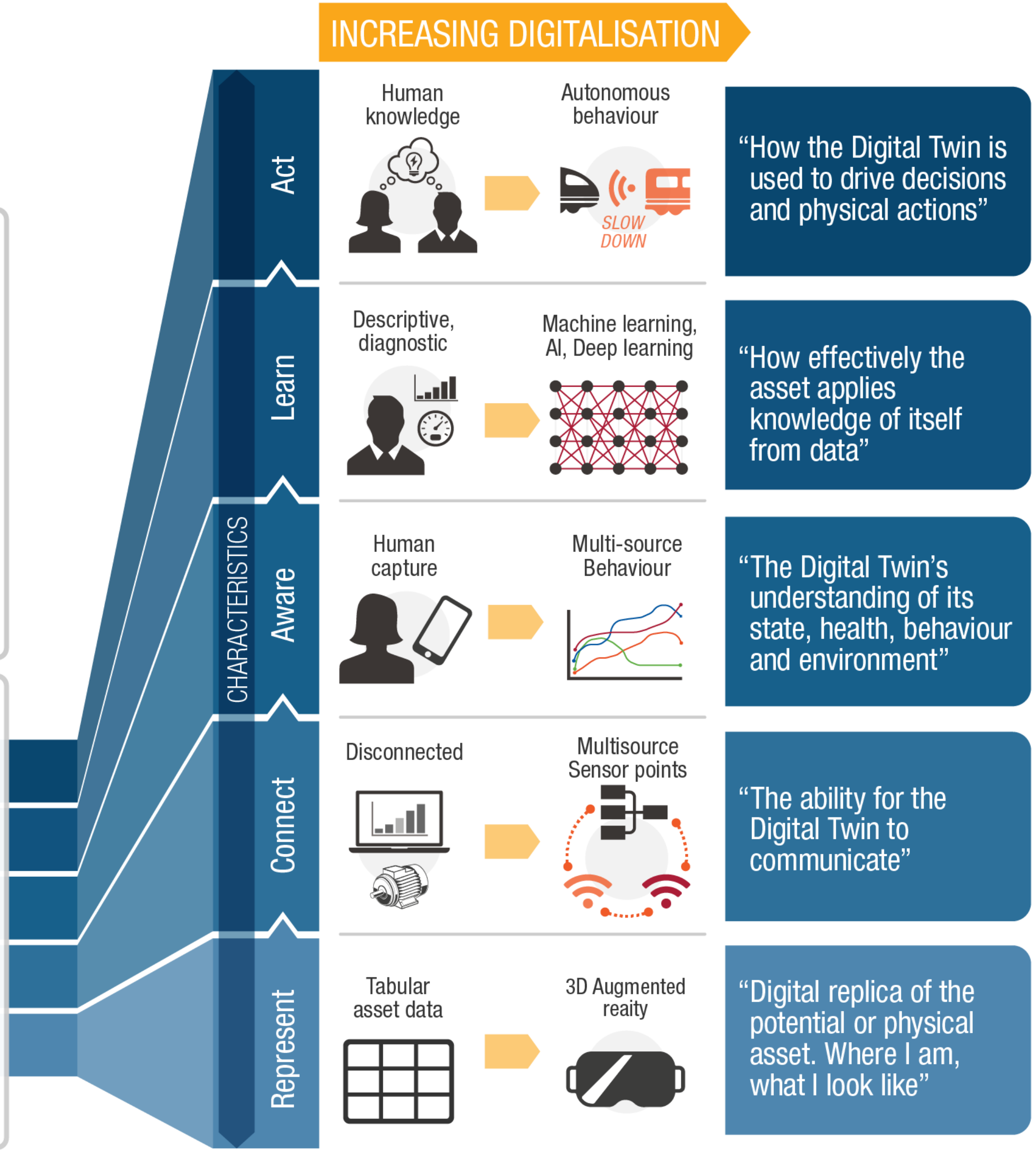
The benefits and use cases for Digital Twin will vary significantly between industries and asset classes, justifying differing levels of Digitalisation. The complex asset assemblies and product lifecycle focus of industries such as aerospace justify digital feedback loops – 'the Digital Thread' – between the as-designed and the as-maintained asset or system.



Building Information Modelling (BIM) concepts and Digital Twin implementation are closely aligned. An effective BIM programme may reduce the risk and cost of creating an effective Digital Twin for the asset's lifecycle. However, the level of detail required from the Digital Twin during the design/construction stage can vary significantly from the needs of Operation, Maintenance and Disposal.

# DIGITAL TWIN CHARACTERISTICS



# AMCL DIGITAL TWIN CHARACTERISTICS MODEL

INCREASING DIGITALISATION

| | REPRESENT | CONNECT | AWARE | LEARN | ACT |
|---|---|---|---|---|---|
| 1 | Asset records with non-geometric lifecycle attributes | Disconnected | Human interaction and knowledge to understand state and asset behaviour | Descriptive & diagnostic analysis through human intervention | Enhanced human decision-making combining tacit-knowledge and digital capability |
| 2 | 2D Geometric and Geospatial attributes | One-directional transmission of current state asset data | Asset or entity's ability to sense its state | Predictive state and behaviour projections | Asset or system has authority to automatically request intervention or investment action |
| 3 | 3D Geometric representation | Two-way data exchange: sharing of asset state and actuation, typically in real-time | Multiple information points to understand asset/system health and performance | Prescriptive suggestion of pre-defined behaviour modification based on knowledge of own state | Asset can autonomously modify state/behaviour and execute action based on knowledge of self and environment |
| 4 | 4D - 2D/3D representation through time (note: Cost is an attribute) | Real time multi source data exchange (external data, e.g. weather, external Digital Twins) | Awareness of the environment and system in which the asset is functioning | Self-Learning – ability to interpret the related system state/behaviour and suggest change | Asset can modify behaviour of self and system/network assets to optimise service or function |
| | ***"Digital replica of the potential or physical twin. Where I am, what I look like"*** | ***"The ability for the Digital Twin to communicate"*** | ***"The Digital Twin's understanding of its state, health, behaviour and environment"*** | ***"How effectively the asset applies knowledge of itself from data"*** | ***"How the Digital Twin is used to drive decisions and physical actions"*** |

# APPROPRIATE DIGITALISATION TO MEET MAINTENANCE RESPONSE USE CASE

INCREASING DIGITALISATION

| Level | REPRESENT | CONNECT | AWARE | LEARN | ACT |
|---|---|---|---|---|---|
| 1 | Asset records with non-geometric lifecycle attributes | Disconnected | Human interaction and knowledge to understand state and asset behaviour | Descriptive & diagnostic analysis through human intervention | Enhanced human decision-making combining tacit-knowledge and digital capability |
| 2 | 2D Geometric and Geospatial attributes | **IoT Sensor recording vibration and temperature of fan motor drive assembly** | Asset ability to sense its state | Predictive state and behaviour projections | **Maintenance planner receives action and method; off-site planning using 3D model view of area** |
| 3 | **3D Geometric model of a tunnel ventilation fan with non-geometric attributes, includes Whole Life Model and history** | Two-way data exchange: sharing of asset state and actuation, typically in real-time | **Motor performance is combined with condition and environmental data; aligned with past maintenance and capital activity** | **Failure rates from similar fan assemblies in comparable environments are used to predict failure and prescribe remedial action** | Asset can autonomously modify state/behaviour and execute activities based on knowledge of self and environment |
| 4 | 4D - 2D/3D representation through time (note: Cost is an attribute) | Real time multi source data exchange (external data, e.g. weather, external Digital Twins) | Understanding of the environment and system in which the asset is functioning | Self-Learning – ability to understand the related system state/behaviour and suggest change | Asset can modify behaviour of system/network assets to optimise service or function |
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# OPTIMAL DIGITALISATION VARIES BY USE CASE

| | | Represent | Connect | Aware | Learn | Act |
|---|---|---|---|---|---|---|
| **Operational Response** | A special event will increase customer demand on an asset system. Simulation of passenger flow across a network provides insight into necessary capacity and service demand changes. | 3 | 3 | 4 | 3 | 3 |
| **Maintenance Response** | **Real-time understanding of condition via IoT sensor. Prediction of impending asset failure due to state change. Automated request for prescribed intervention response. Off-site planning of works using 3D-Model representation.** | 3 | 2 | 3 | 3 | 2 |
| **Investment Management** | Provision of a collated information model combining asset/system data, geospatial context and performance history. Application of modelling to data to generate prescribed investment needs. Optimisation intelligence applied to generate an asset investment plan. | 2 | 2 | 3 | 3 | 2 |
| **Onboarding Technical Staff** | Provision of a 3D model based virtual environment to allow new starters to familiarise with assets, asset systems and the planning of interventions. Includes the understanding of safety and environment factors. | 3 | 2 | 2 | 2 | 1 |
| **Design & Construction** | Enhanced asset acquisition through the use of a 4D model to support design and construction. 3D representation of potential twin supports clash detection, simulation and optimised design of the physical twin. | 4 | 2 | 2 | 2 | 2 |



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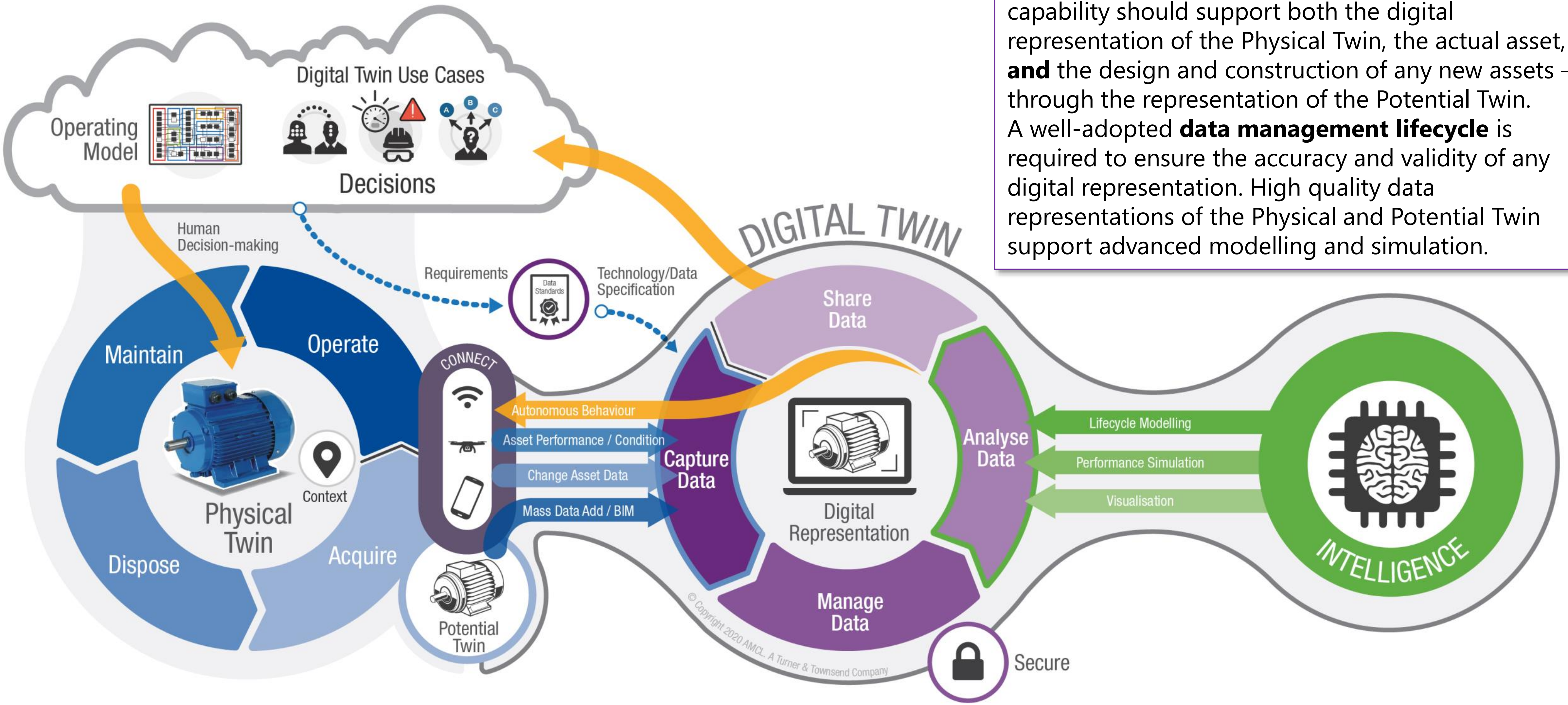
# REQUIRED DIGITAL TWIN CAPABILITY



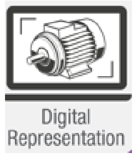

The Digital Twin's capability is **provided by data and technology**, specified to meet the requirements of relevant business use cases. The Digital Twin capability should support both the digital representation of the Physical Twin, the actual asset, **and** the design and construction of any new assets – through the representation of the Potential Twin.
A well-adopted **data management lifecycle** is required to ensure the accuracy and validity of any digital representation. High quality data representations of the Physical and Potential Twin support advanced modelling and simulation.

# DIGITAL TWIN SUCCESS FACTORS

**1. Ensure Digital Twin adoption is driven by clear business need:** A Digital strategy based on use cases with associated benefits should be developed to support the investment in Digital Twin technology and the associated change to People, Process and Data.

**2. Make sure the level of digitalisation matches your readiness:** The selection of appropriate Digital Twin characteristics should include an assessment of the organisation's current maturity and the ability to afford and adopt leading-edge technology.


**3. Requirements aligned to objectives are foundational:** Business requirements defined using the organisation's Operating Model and Digital Twin use cases should drive specification of data and technology. Collaboration on and adoption of industry data standards is recommended.




**4. Digital Twin is more than just the physical representation:** It is essential to align lifecycle and operating context information to physical attributes to support the application of intelligence.

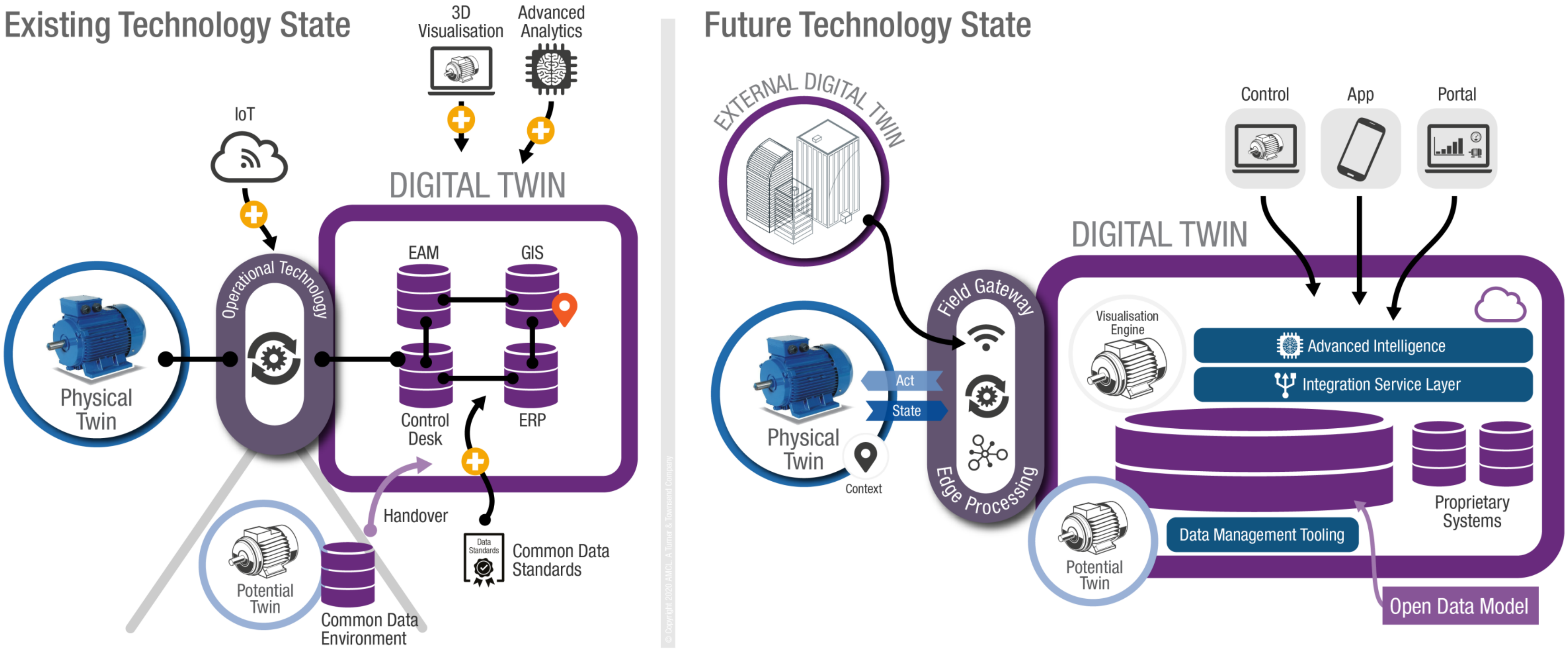

**5. The security of data and technology capability against cyber threats is paramount:** Both the physical and digital twin should be procured and continually managed to safeguard against cyber attack.


**6. Get the data right first time:** There is a unique and significant opportunity cost associated with data capture during construction and at handover. BIM concepts support Digital Twin realisation. For a legacy 'brownfield' asset base, physical data surveys (including LIDAR) and data preparation and cleansing will be required.


**7. Consider external connectivity:** External integration outside of the organisation may be required to understand asset or system context (e.g. National Digital Twins, environment, service partner and customer data feeds).

**8. To be trusted, the Digital Twin must be owned and actively managed:** A Data Management Framework is required to govern the Digital Twin's data lifecycle and ensure a chain of custody for data and information - data should be considered as an asset in its own right.

# DIGITAL TWIN TECHNOLOGY APPROACH




- Lower risk of adoption by augmenting existing applications with more advanced digital capability to realise Digital Twin
- Point to point interfaces and complex data management
- Potential Twin development unlinked from digital twin requirements

- Consistent data model by design, alignment between potential and digital twins
- Visualisation engines support business application layer
- Intelligence available across open data model to support human/autonomous decision
- Connection technologies support External Digital Twin interaction

# CONCLUSIONS

There is no **'one size fits all'** footprint for a Digital Twin - the approach and technology adopted will vary by use case, cost/benefit, and the appetite for digitalisation.

An effective Digital Twin will offer **significant benefits** to an organisation, including:

- **Improved customer service** through the simulation/modelling of potential and actual asset performance;
- Capture, track and learn from the past, to **optimise future business and asset design;**
- **Reduced maintenance and process costs** through enhanced human decision making – visualisation, data access and machine-suggested action; and
- **Increased asset uptime** with more eyes on the asset and system to predict failure and reduce physical inspection.

Ensuring the Digital Twin remains a current replica of the Physical Twin is essential. The **data must be trusted by users**. This presents a significant data management and process challenge.

There are inherent risks to successful adoption. A **Digital Strategy** is vital, which includes a clear understanding of your organisation's current maturity, such as data quality, technology delivery and data management. The strategy must be based on clear objectives, use cases and related benefits.

# Want to discuss further?

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# REFERENCES


- **IET and Atkins**, *Digital Twin for the Built Environment*
- **Centre of Digital Built Britain**, *The Gemini Principles, 2018*
- **Arup**, *Digital Twin – Towards a Meaningful Framework*
- **WWT**, *Industry 4.0 – How to Build a Digital Twin*
- **GE Digital**, *Minds + Machines: Meet a Digital Twin*
- **Forbes**, *What Is Digital Twin Technology – And Why Is It So Important*
- **Network World**, *What is a digital twin and why it's important to IoT*
- **Microsoft**, *The Promise of a Digital Twin Strategy*
- **Deloitte Insights**, *Industry 4.0 and the digital twin*
- **Gartner**, *Information Technology – Gartner Glossary*