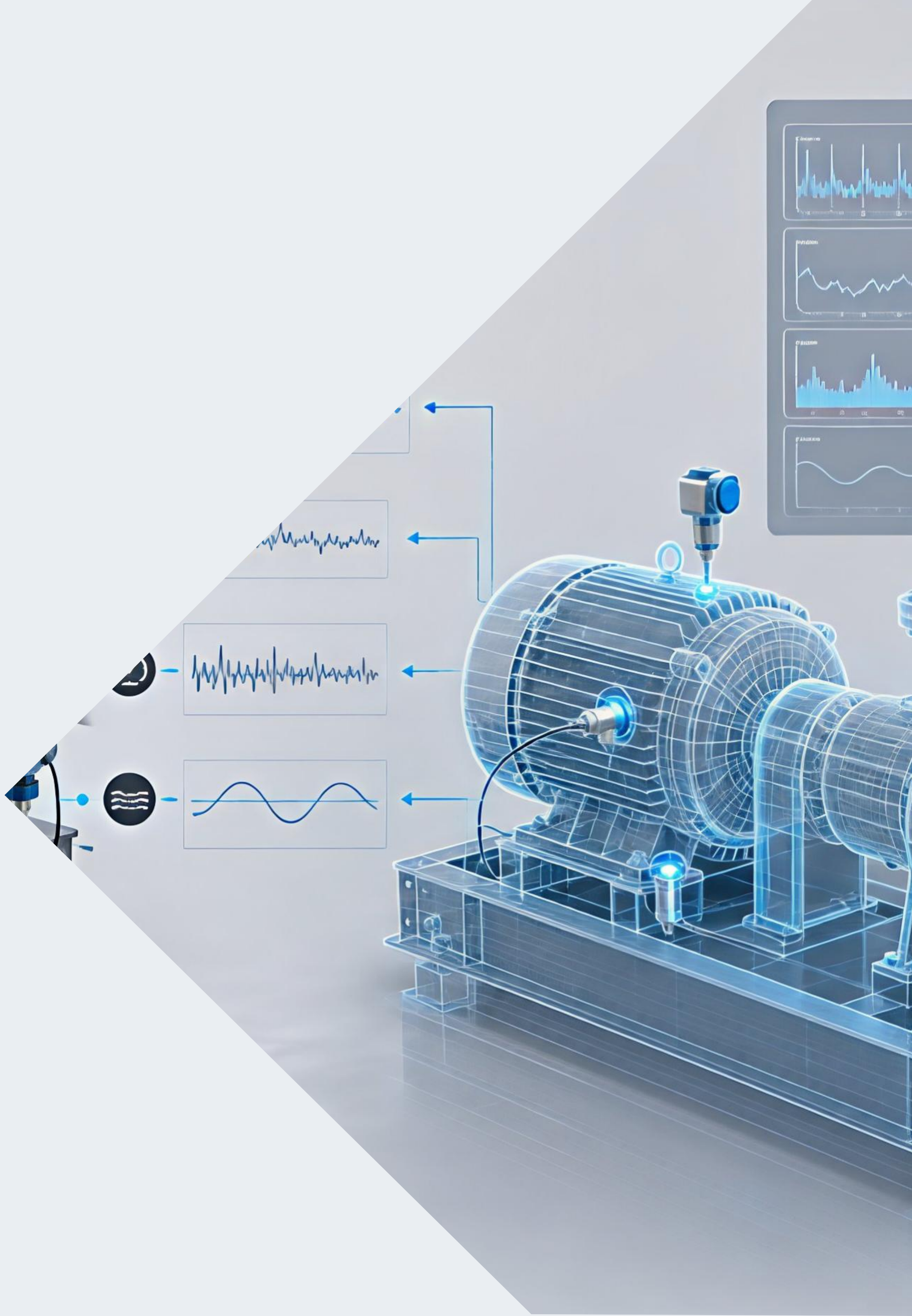
ECT
Engineering College of Technology.

From Smart Sensors to Digital Twins: How Engineering Is Changing

Watch Webinar Recording Here

Dr. Ali Marzoughi



About ECT

ECT
Engineering College of Technology.

We are dedicated to ensuring that you receive a world-class education and gain skills that you can immediately apply in the workforce.

UK Recognised Education

ECT is OfS registered, meeting the Office for Students' requirements for course quality, academic standards, student support and student protection.

Engineering Specialists

ECT - affiliated to the well-established Engineering Institute of Technology (EIT) - is an engineering education specialist. ECT delivers bachelor's and master's degrees.

Lecturers and Instructors

Our teachers are subject specialists with industry experience and the requisite academic qualifications. They bring extensive expertise from across the engineering sector, ensuring students learn from experienced professionals with both academic and real-world knowledge.

Industry-Driven programmes

Our programmes are designed by industry experts, ensuring you graduate with cutting-edge skills that are valued by employers. Our programme content remains current with rapidly changing technology and industry developments.

Unique Delivery Model

We deliver our programmes via a unique delivery methodology that makes use of live and interactive tutorials, an international pool of expert lecturers, dedicated learning support officers, hands-on workshops and state-of-the-art remote labs connected to real equipment, and simulation software.

Agenda

1	Why sensors are becoming more important in modern engineering
2	From conventional sensors to smart sensors
3	Connected sensors and the industrial data ecosystem
4	From physical measurements to virtual models
5	Digital twins: what they are and how they work
6	How these technologies are changing engineering practice

Why Sensors Matter More Than Ever

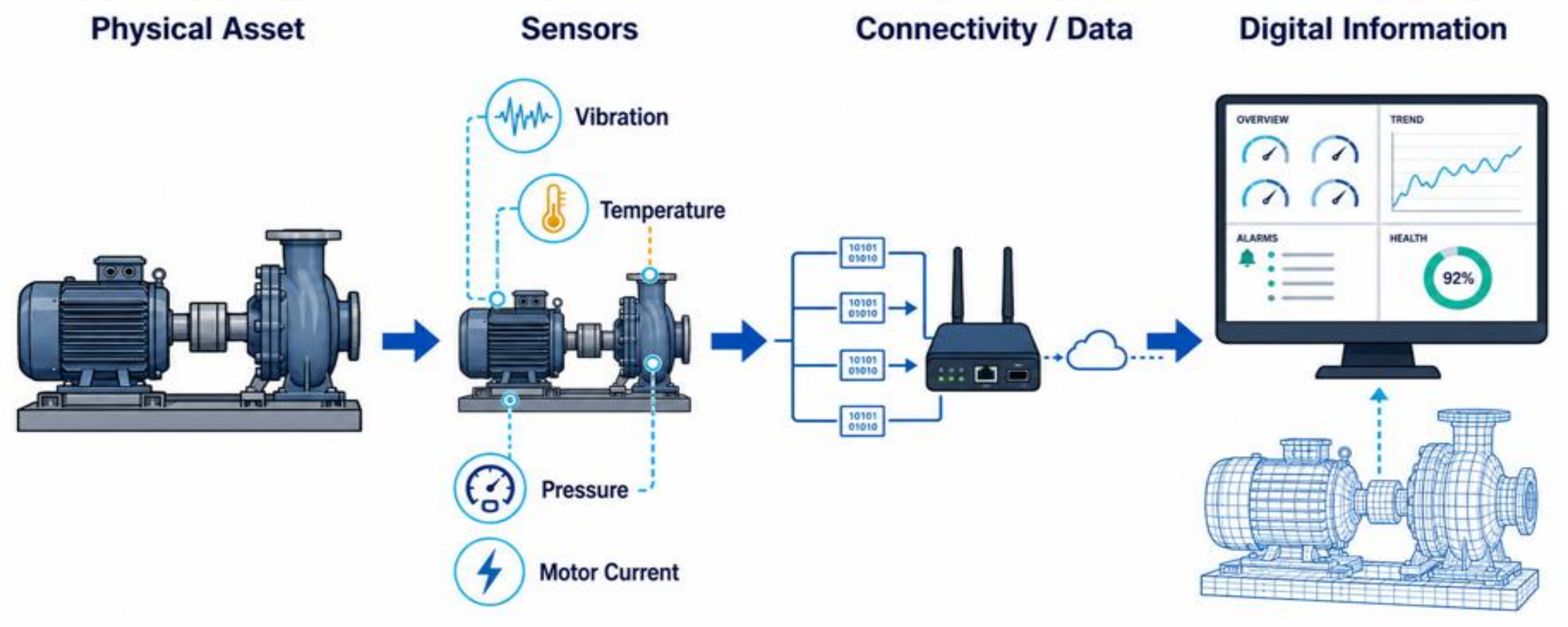
Engineering has always depended on measurement.
What has changed is how measurement data is used.

Measure → Connect → Understand → Act

- **Measure:** temperature, pressure, vibration, flow, position, current
- **Connect:** PLCs, industrial networks, IIoT, edge devices
- **Understand:** trends, conditions, anomalies, performance
- **Act:** control, optimisation, diagnostics, engineering decisions

Key message:
Sensors are the interface between the physical system and its digital representation.

Why Sensors Matter More Than Ever



From Conventional Sensors to Smart Sensors

Conventional sensor

Measures a physical variable

Produces an analogue or digital signal

Relies mainly on external devices for processing and interpretation

Smart sensor

Combines sensing with local processing

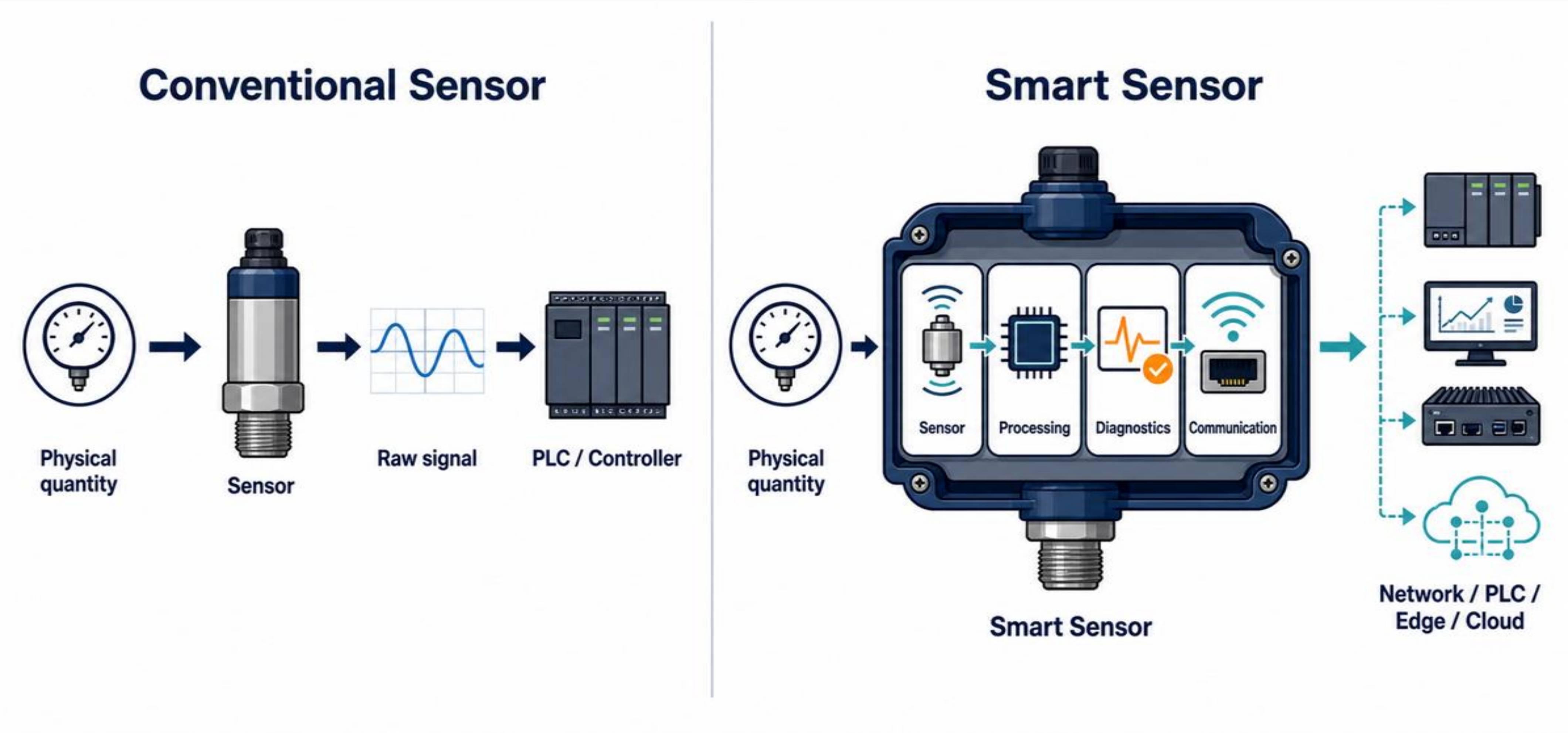
Can perform signal conditioning and self-diagnostics

Communicates data digitally

May support calibration, identification, and basic decision-making

Key message:
A smart sensor does more than measure - it adds processing, communication, and intelligence at the sensing point.

From Conventional Sensors to Smart Sensors



From Smart Sensors to Connected Systems

Smart sensors become more valuable when they are connected to the wider engineering system.

Sensor

Local processing

Industrial network

Controller / Edge

Data platform

Typical functions enabled by connectivity:

Real-time data exchange

Remote monitoring

Data logging and historical analysis

Integration of multiple sensor sources

Sharing information across control and engineering systems

Key message:
Connectivity turns isolated measurements into system-level information.

From Smart Sensors to Connected Systems

From Measurements to Engineering Data

A sensor reading becomes useful only when it is converted into meaningful engineering information.

Physical quantity → Sensor signal → Signal conditioning → Digital value → Contextualised data

Examples:

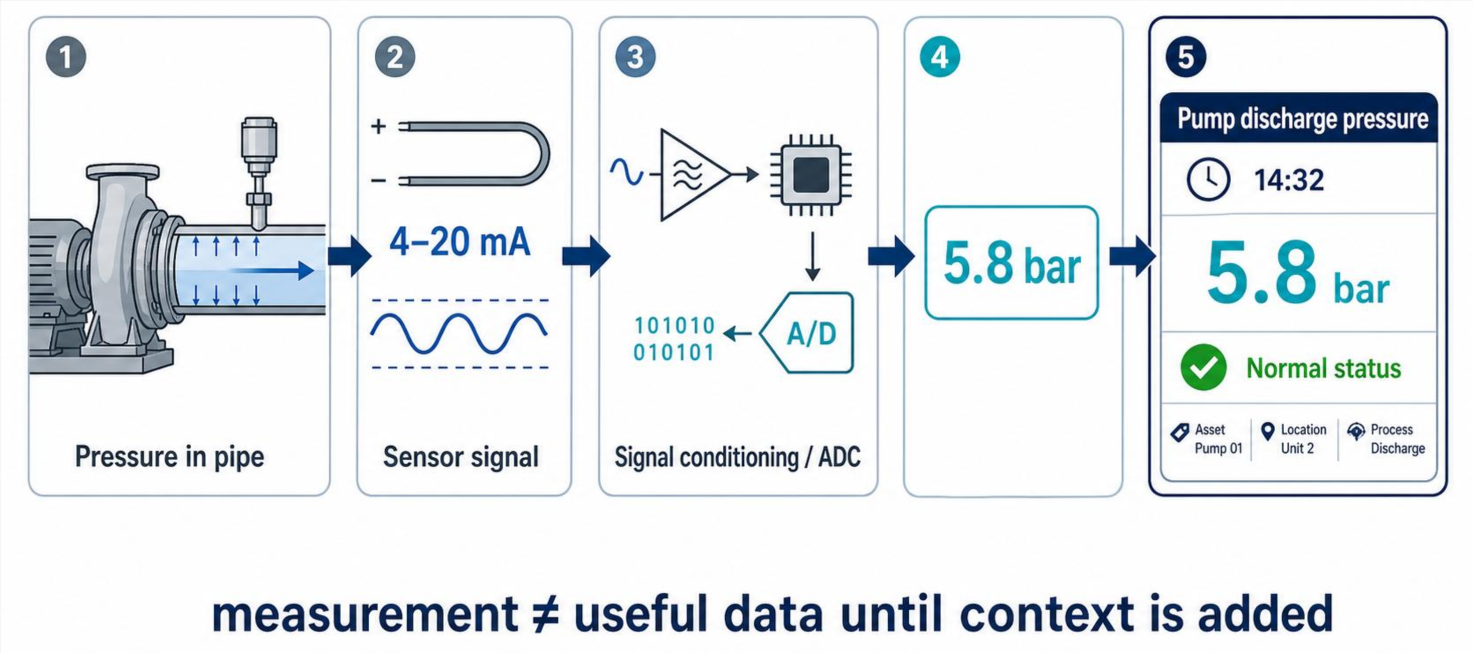
Time stamp

Sensor ID and location

Engineering units

Operating condition

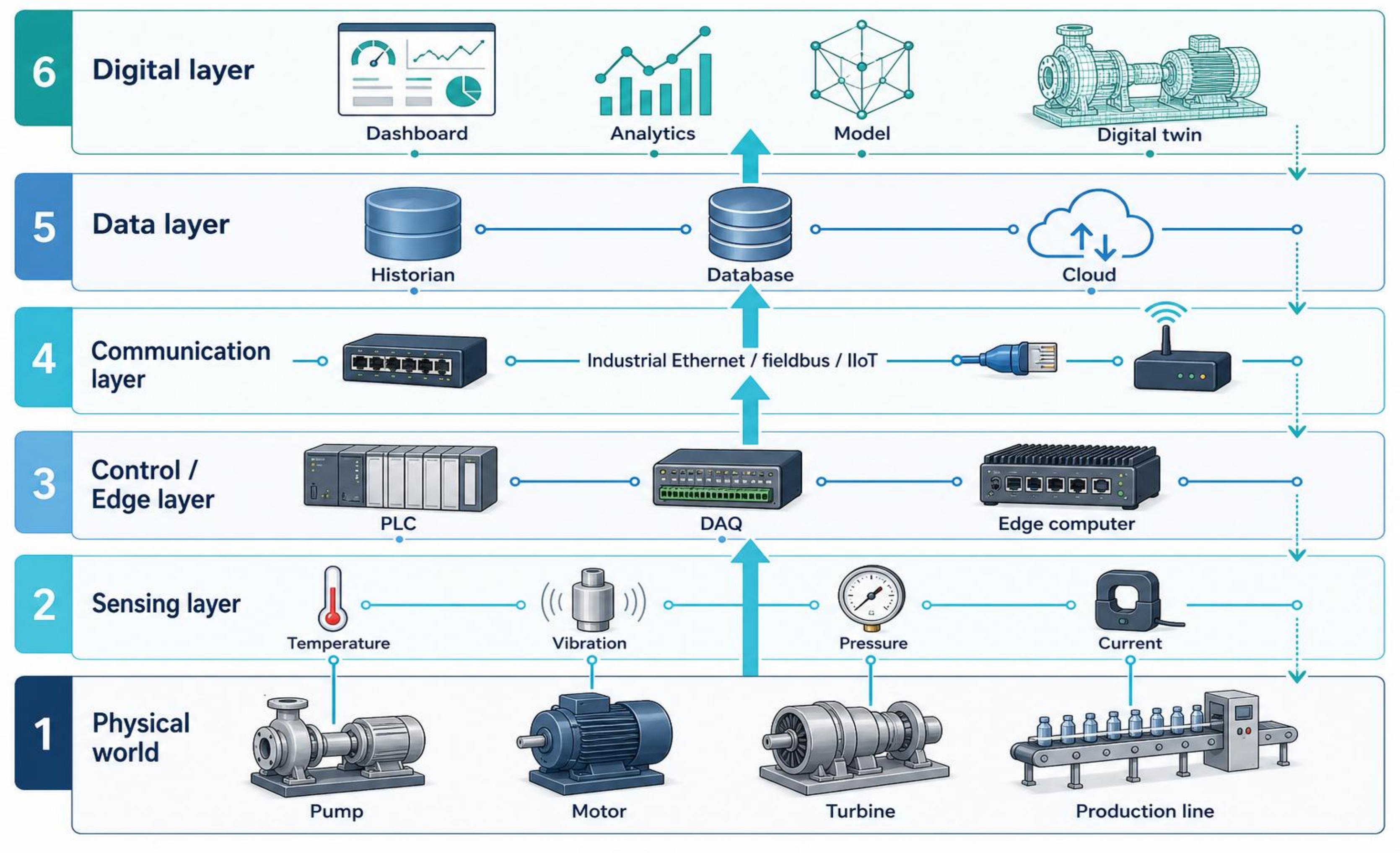
Quality / diagnostic status



Key message:
Raw measurements become engineering data when they are processed, identified, and placed in context

The Physical-to-Digital Data Flow

Creating a digital representation requires a continuous flow of information from the physical system.



The Physical-to-Digital Data Flow

Physical asset → Sensors → Data acquisition → Communication → Processing / Storage → Digital application

Typical elements:

- Physical equipment and processes
- Smart sensors and instrumentation
- PLC / DAQ / edge devices
- Industrial communication networks
- Historian, database, or cloud platform
- Monitoring, analytics, and digital models

Key message:
The digital layer depends on a reliable data pipeline from the physical asset.

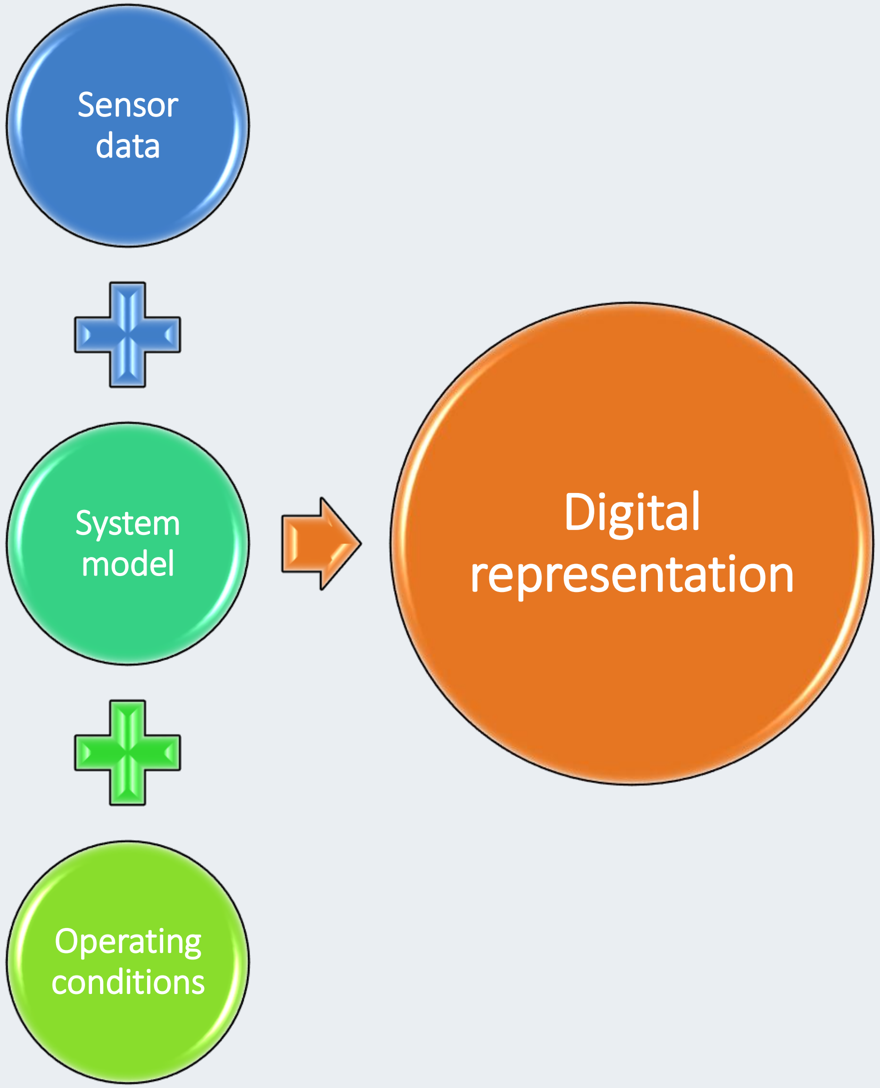
From Data to a Digital Representation

Collected data can be combined with engineering models to represent the current behaviour of a physical system.

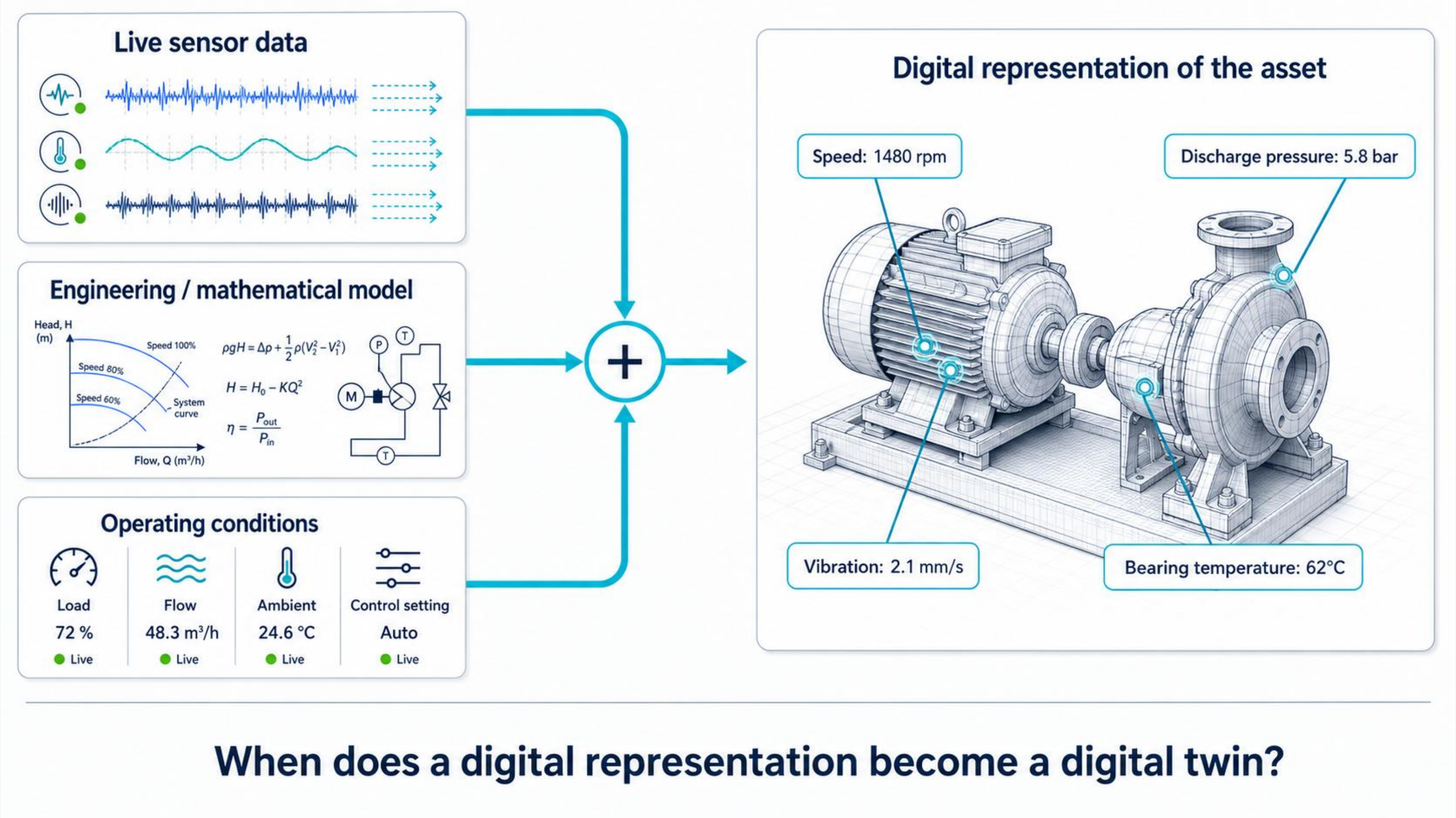
A digital representation may include:

- Current operating state
- Key performance variables
- Trends and system behaviour
- Estimated or unmeasured variables
- Relationships between system components

Key message:
A digital representation is more than a dashboard - it combines data with a model of the physical system.



From Data to a Digital Representation



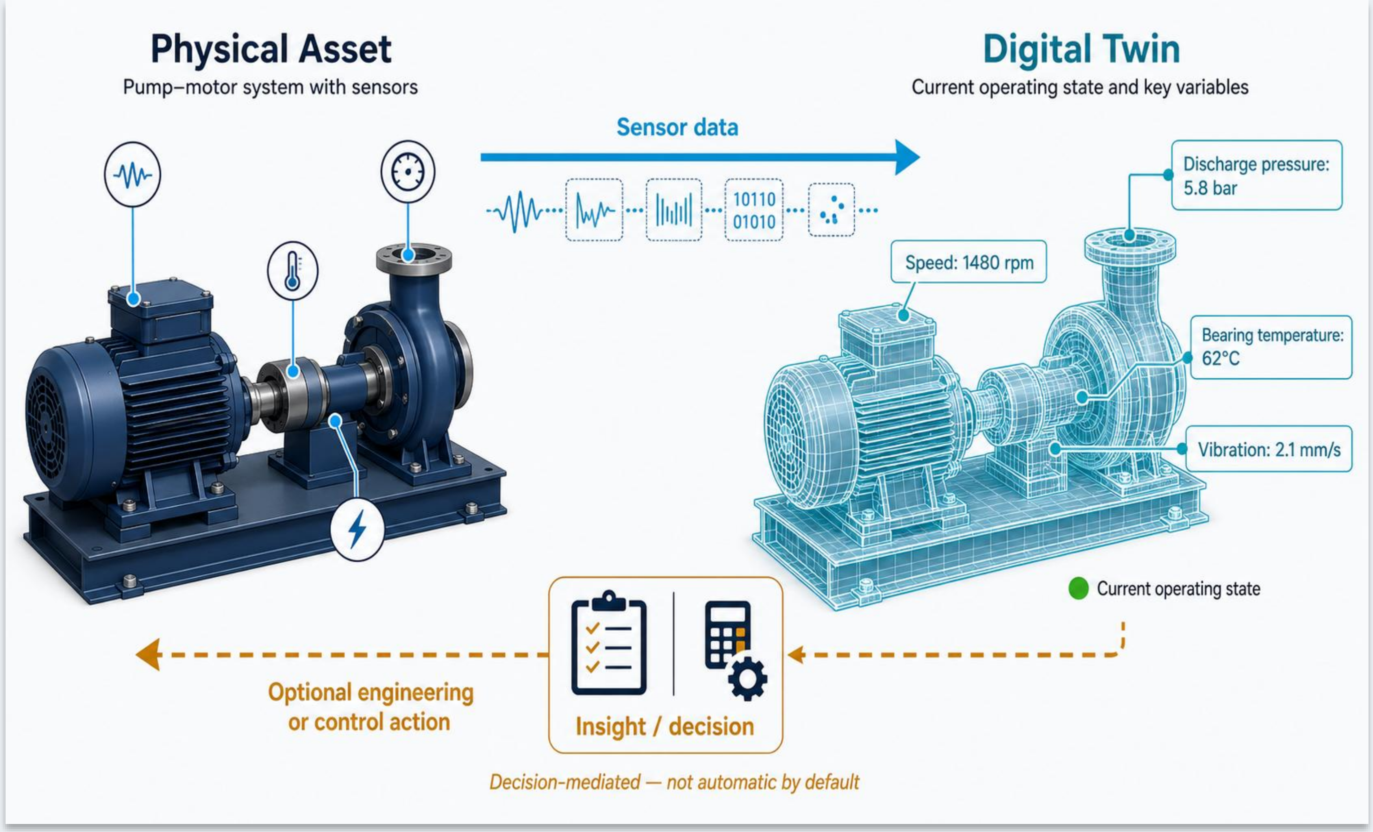
What Is a Digital Twin?

A digital twin is a digital representation of a specific physical asset, process, or system that is updated using data from the real system.

A digital twin typically reflects:

- Current operating state
- Relevant physical and operational behaviour
- Changes occurring in the real system over time
- Outputs used for analysis, prediction, or decision support

Key message:
The essential idea is an ongoing link between the physical system and its digital counterpart.



Model vs Simulation vs Digital Twin

Digital Model	Simulation	Digital Twin
Represents a system or component	Uses a model to study system behaviour	Represents a specific physical asset or system
May be static or manually updated	Usually explores scenarios or predicted responses	Updated using data from the real system
No live connection required	No live connection required	Has an ongoing data connection to the physical system
Used for design and analysis	Used for testing, prediction, and what-if studies	Used for monitoring, analysis, prediction, and decision support

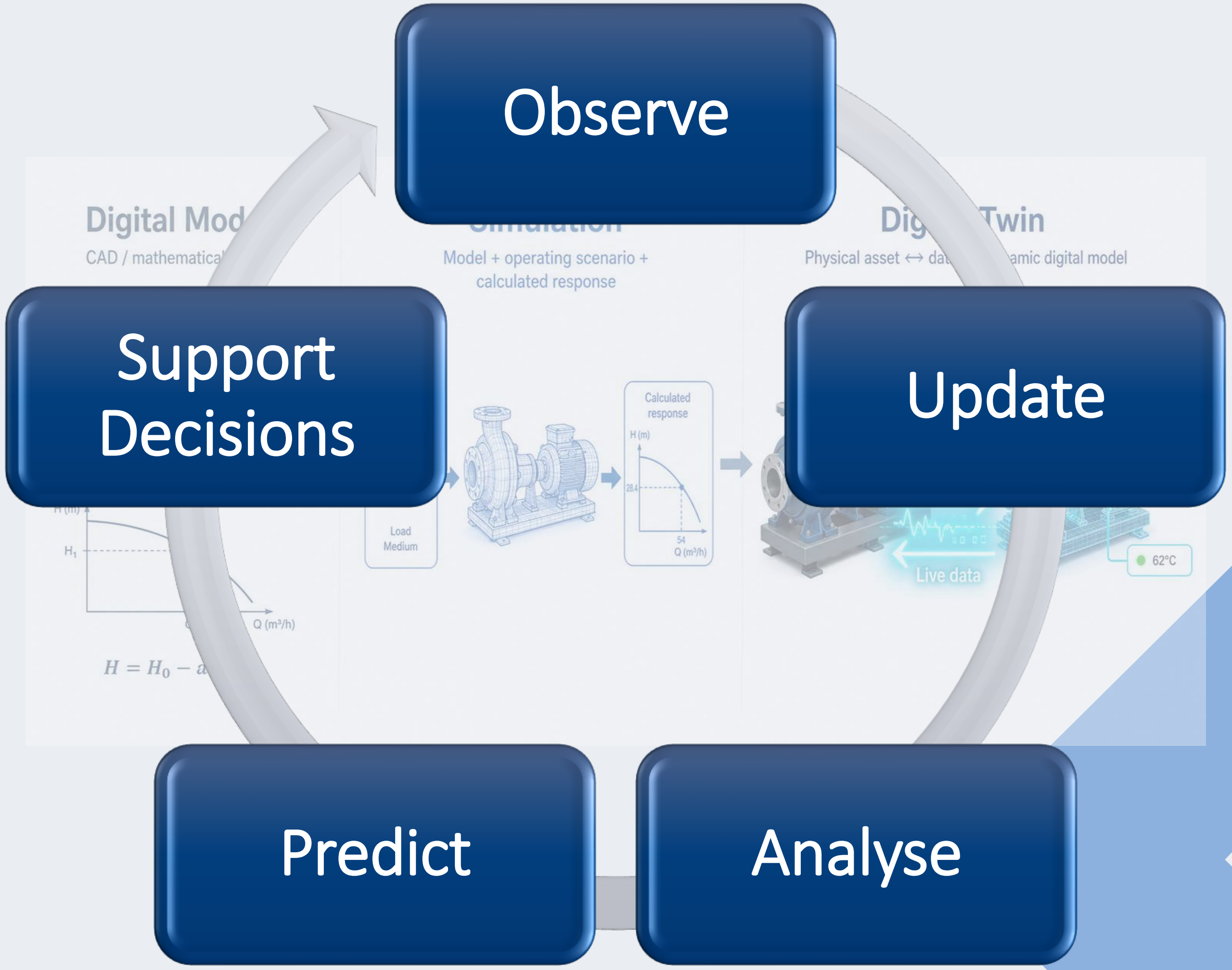
How a Digital Twin Works

ECT Engineering College of Technology.

A digital twin operates as a continuous cycle:

- **Observe:** receive current data from the physical system
- **Update:** adjust the digital model to reflect the latest system state
- **Analyse:** compare expected and actual behaviour
- **Predict:** estimate future response under different conditions
- **Support decisions:** provide information for engineering action

Key message:
The value of a digital twin comes from continuously updating the model and using it to interpret and predict system behaviour.



What Kind of Model Can a Digital Twin Use?

A digital twin can use different modelling approaches depending on the application:

Physics-based model

- Built from engineering equations and known system behaviour
- Useful when physical relationships are well understood

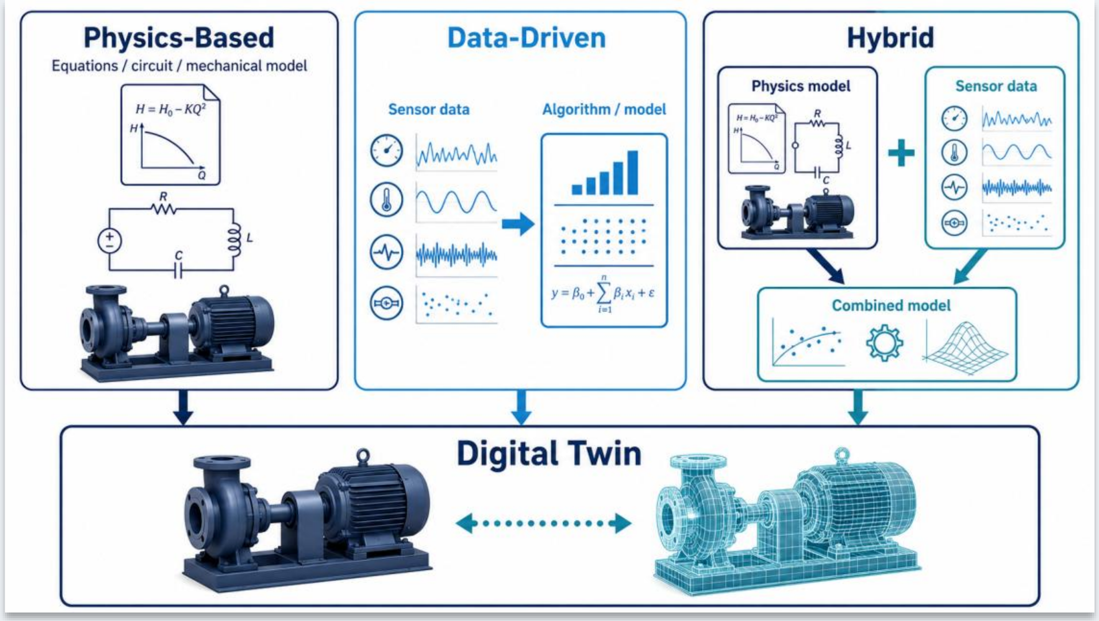
Data-driven model

- Learns system behaviour from historical and operational data
- Useful for complex relationships that are difficult to model analytically

Hybrid model

- Combines physical knowledge with data-driven methods
- Can provide a practical balance between interpretability and adaptability

Key message:
A digital twin does not require one specific modelling method- the model should suit the engineering problem and available data.



Practical Example: Digital Twin of a Wind Turbine

Physical system

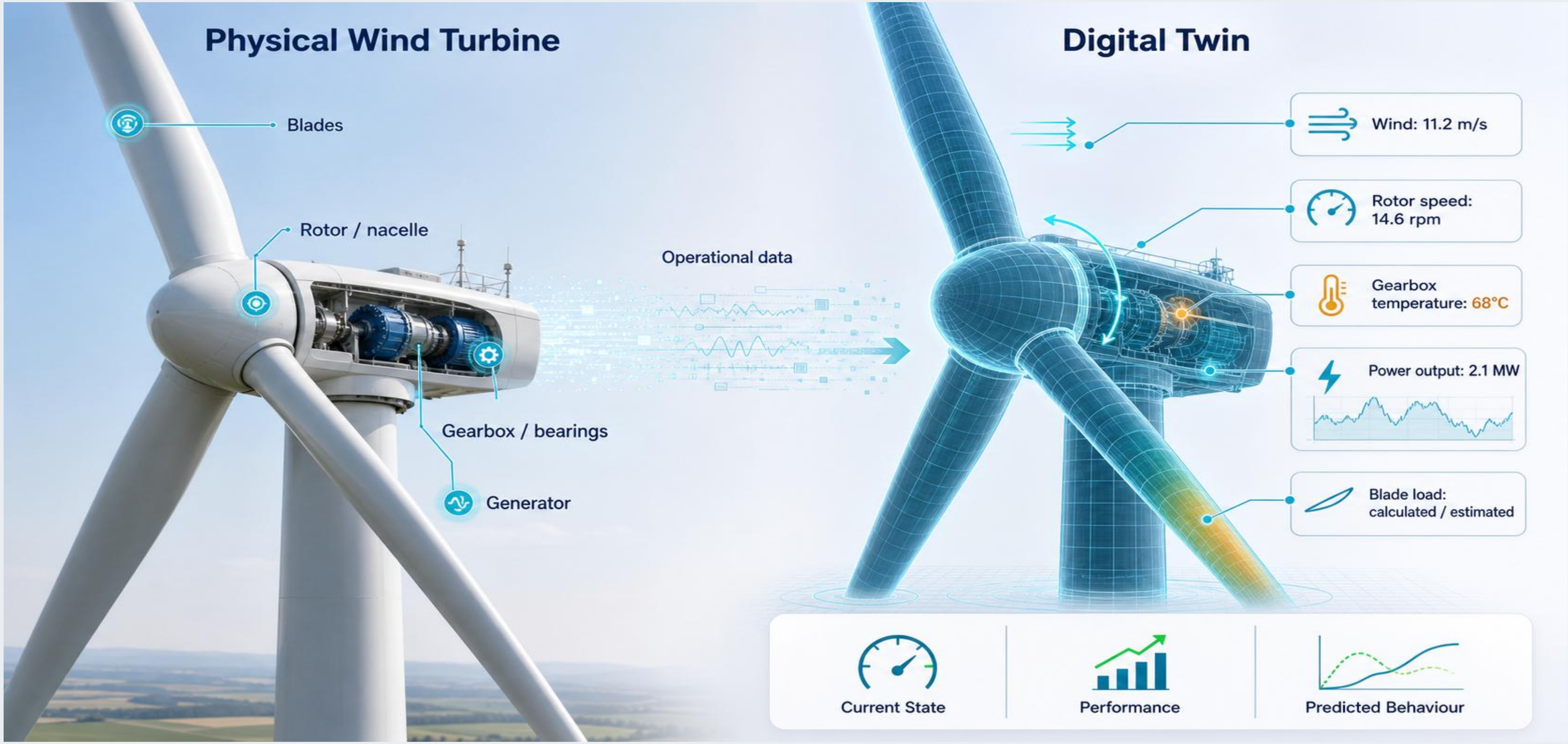
- Wind turbine operating under continuously changing environmental and load conditions
- Sensors measure variables such as:
  - Wind speed and direction
  - Rotor speed
  - Vibration
  - Bearing and gearbox temperature
  - Blade strain
  - Electrical power output

A digital twin can be used to:

- Track the current operating state
- Compare actual and expected performance
- Estimate loads and component condition
- Evaluate behaviour under changing wind conditions
- Predict future performance or abnormal behaviour

Key message:
A digital twin combines real operating data with a system model to understand both current and possible future behaviour.

Practical Example: Digital Twin of a Wind Turbine



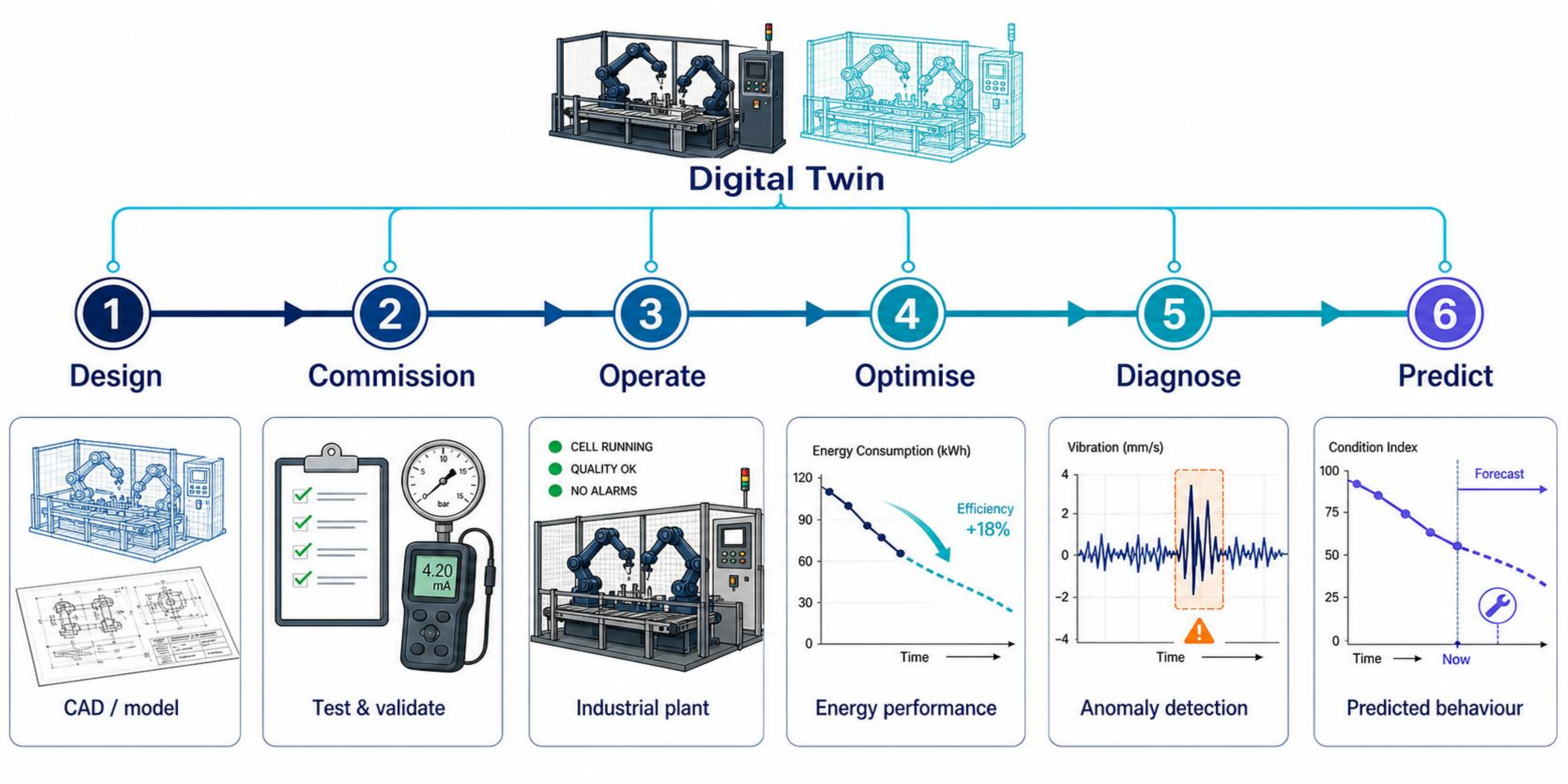
What Can a Digital Twin Be Used For?

Digital twins can support different engineering tasks across the asset lifecycle:

- **Design:** evaluate system behaviour before physical implementation
- **Commissioning:** compare expected and actual system response
- **Operation:** monitor performance and operating condition
- **Optimisation:** test alternative operating strategies
- **Diagnostics:** investigate abnormal behaviour and likely causes
- **Prediction:** estimate future performance or system state

A digital twin can support engineering decisions from design through operation-not only maintenance.

What Can a Digital Twin Be Used For?

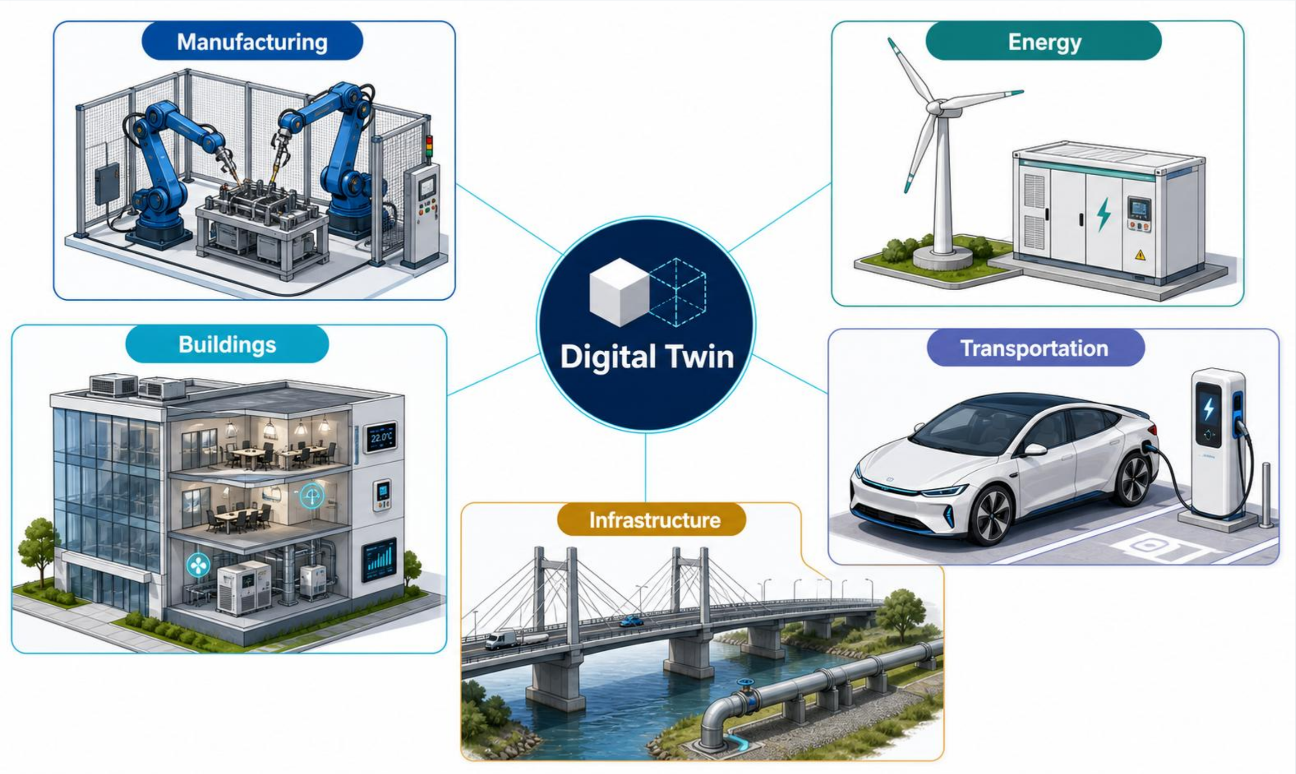


Digital Twins Across Engineering Sectors

Digital twin concepts are being applied across many engineering domains:

- **Manufacturing:** production lines, robots, machine tools
- **Energy:** wind turbines, power systems, batteries
- **Buildings:** HVAC, energy consumption, occupancy
- **Transportation:** vehicles, rail systems, aircraft
- **Infrastructure:** bridges, pipelines, water networks

Key message:
The digital twin concept is not tied to one industry-the same principle can be adapted to very different physical systems.



How Engineering Practice Is Changing

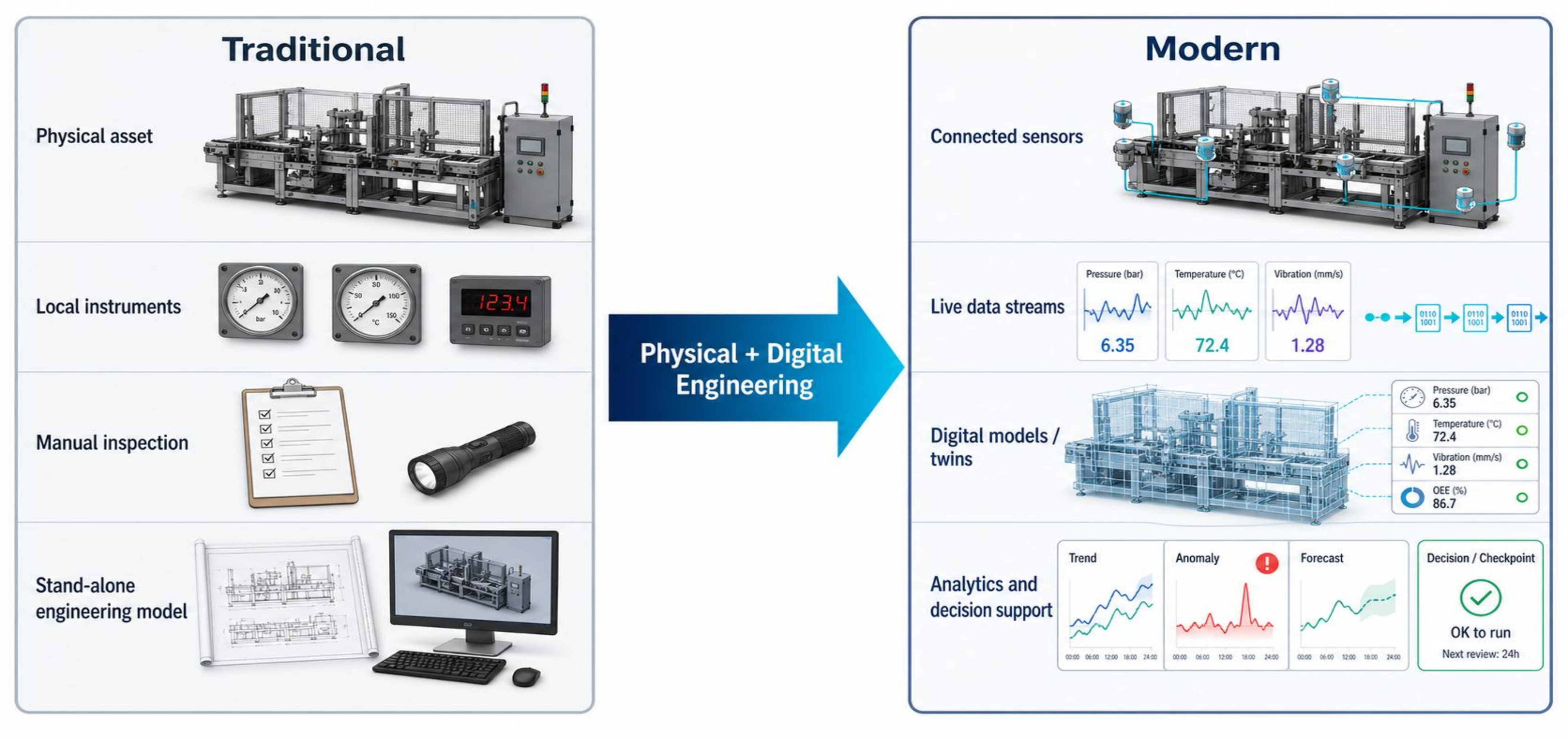
Engineers are increasingly working across both the physical and digital domains.

Key shifts include:

- From isolated measurements to connected system data
- From periodic observation to continuous visibility
- From reactive interpretation to predictive insight
- From stand-alone models to continuously updated digital representations
- From discipline-specific analysis to integrated, data-informed decision-making

Key message:
The engineer’s role is expanding-from designing and operating physical systems to also understanding their data, models, and digital behaviour.

How Engineering Practice Is Changing



Summary

1. Sensors are the starting point
They connect physical behaviour to the digital world.

2. Smart sensing adds more than measurement
Processing, diagnostics, and communication make sensor data more useful.

3. Connectivity turns measurements into system-level information
Reliable data flow is essential for digital engineering.

4. A digital twin is more than a model
It stays linked to a specific physical system through operational data.

5. The real value is better engineering decisions
Monitoring, analysis, prediction, optimisation, and system understanding all depend on the quality of the data and model.

Closing message:
The future of engineering is increasingly built around the connection between physical systems and their digital counterparts.

Thank You!

Upcoming Programmes

Engineering College of Technology (ECT) *UK-Recognised Qualifications*	Start Date
Bachelor of Engineering (Honours) in Industrial Automation	September 2026, February 2027
Bachelor of Engineering (Honours) in Electrical Engineering	September 2026, February 2027
Master of Science (Power System Analysis and Renewable Integration)	October 2026, February 2027
Master of Science (Industrial Automation and Instrumentation Control)	October 2026, February 2027

Contact Us:

Website
www.ect.ac.uk

Programmes
https://www.ect.ac.uk/programmes/

Head Office
Whittle Way, Stevenage SG1 2FS,
United Kingdom

Phone
Inside UK: 0203 582 1389
Outside UK: +44 203 582 1389