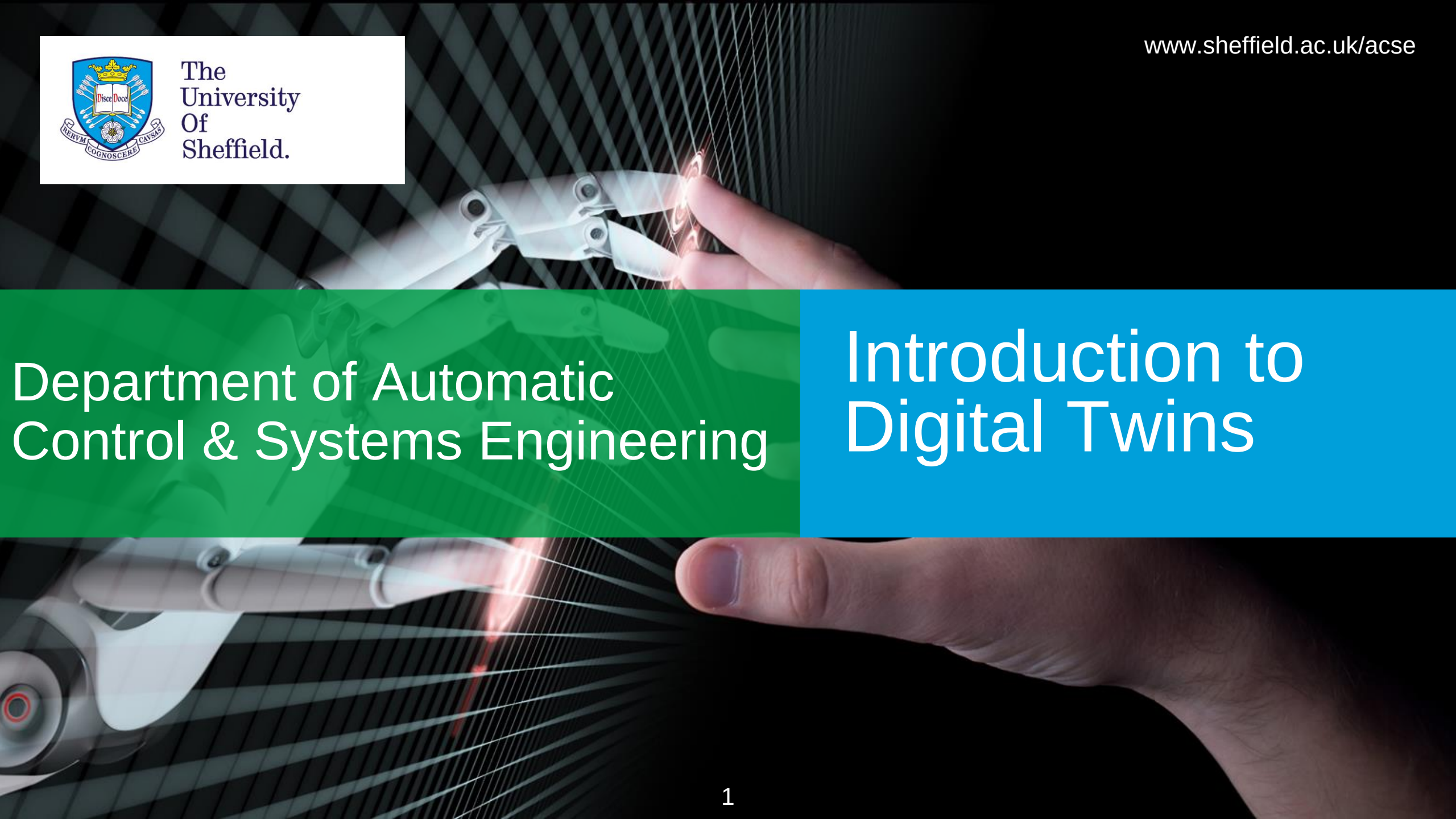

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Department of Automatic Control & Systems Engineering

Introduction to Digital Twins

Digital-Twins – Setting the Scene

- What is a Digital Twin?
- What infrastructure you need to establish a Digital Twin?
- What are the key levels of maturity for Digital Twins?
- What are the applications and benefits?

Digital Twin Definitions

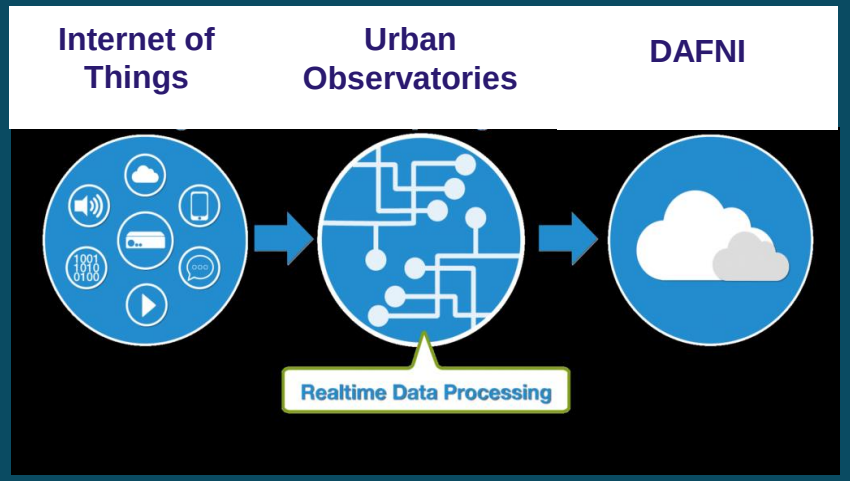
A digital twin is a virtual representation of a physical object or system across its lifecycle, using real-time data to enable understanding, learning and reasoning.
IBM

A digital twin is a virtual representation of a physical product or process, used to understand and predict the physical counterpart's performance characteristics.
Siemens

Digital twins are realistic digital representations of physical things. They unlock value by enabling improved insights that support better decisions, leading to better outcomes in the physical world.
Cambridge Centre for Digital Build Britain

A digital twin is a mirror image of a physical process that is articulated alongside the process in question, usually matching exactly the operation of the physical process which takes place in real-time.
Michael Batty, UCL

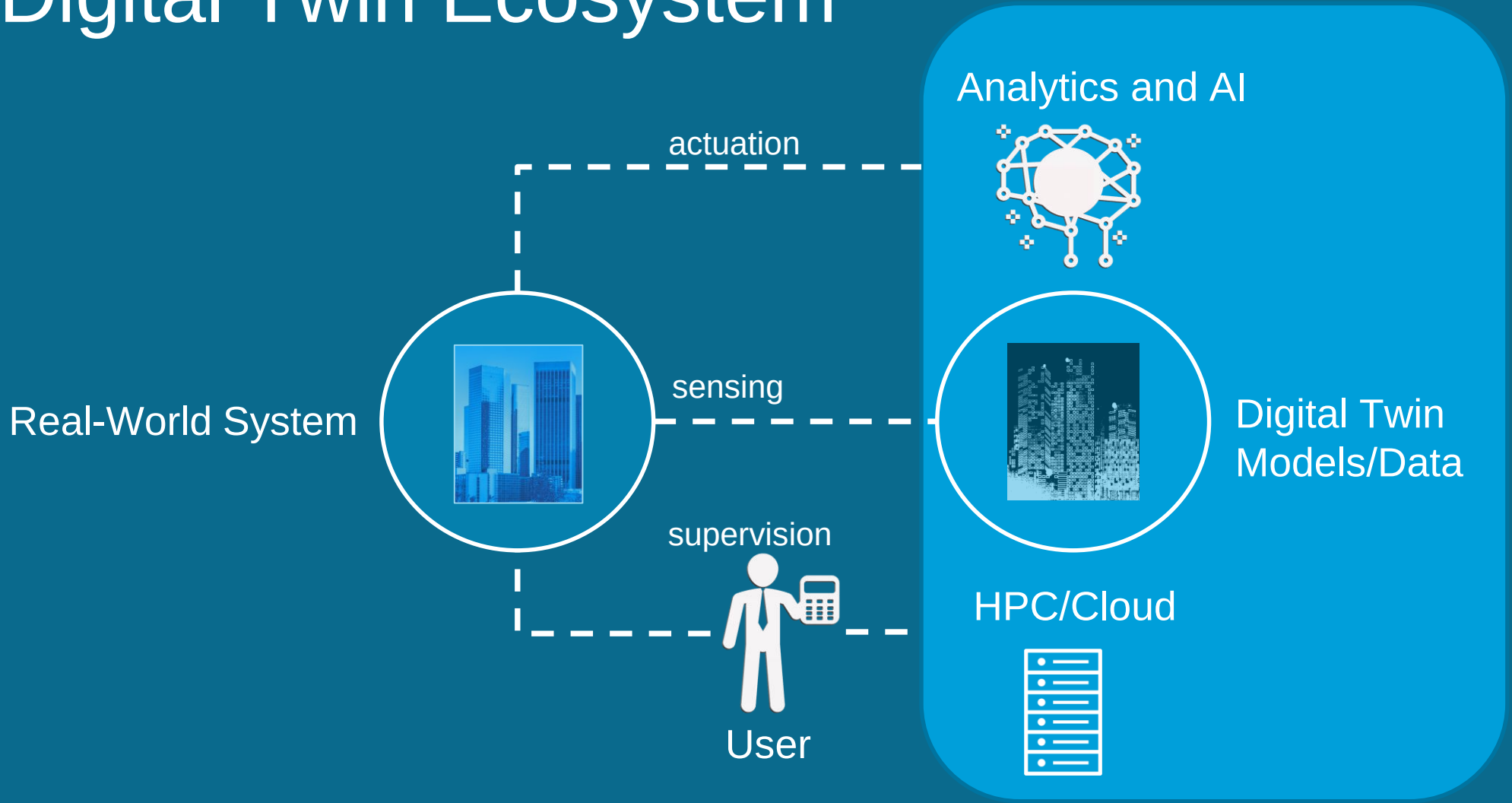
Digital Twin Infrastructure



- Historical and real-time data storage – ***DAFNI NID***
- Large-scale sensor network – ***Urban Observatories***
- HPC for information processing – ***DAFNI HPC/Cloud***
- Collaborative platform for modelling – ***DAFNI NI Modelling Service***
- Analysis and visualization tools – ***DAFNI NI Visualisation Suite***
- Secure environment – ***DAFNI Security Service***

User

Digital Twin Ecosystem



Digital Twin Maturity Levels

Level 1- Basic Reporting and Analysis

- Dynamic low fidelity model
- Linked to the real-world system
- Model updated at regular intervals but not necessarily in real-time
- No capability for autonomous decision making
- Basic learning, data assimilation capability
- Basic analytics and visualisation functionality of the current state

Digital Twin Maturity Levels

Level 2- Advanced Reporting, Analysis and Forecasting

- Real-time, dynamic high fidelity models developed from first principles
- Model updated in real-time
- Standard pre-defined control/decision-making capability
- Advanced data assimilation capability to ensure convergence and accuracy
- Advanced predictive analytics

Digital Twin Maturity Levels

Level 3- Support for Strategic Decision Making

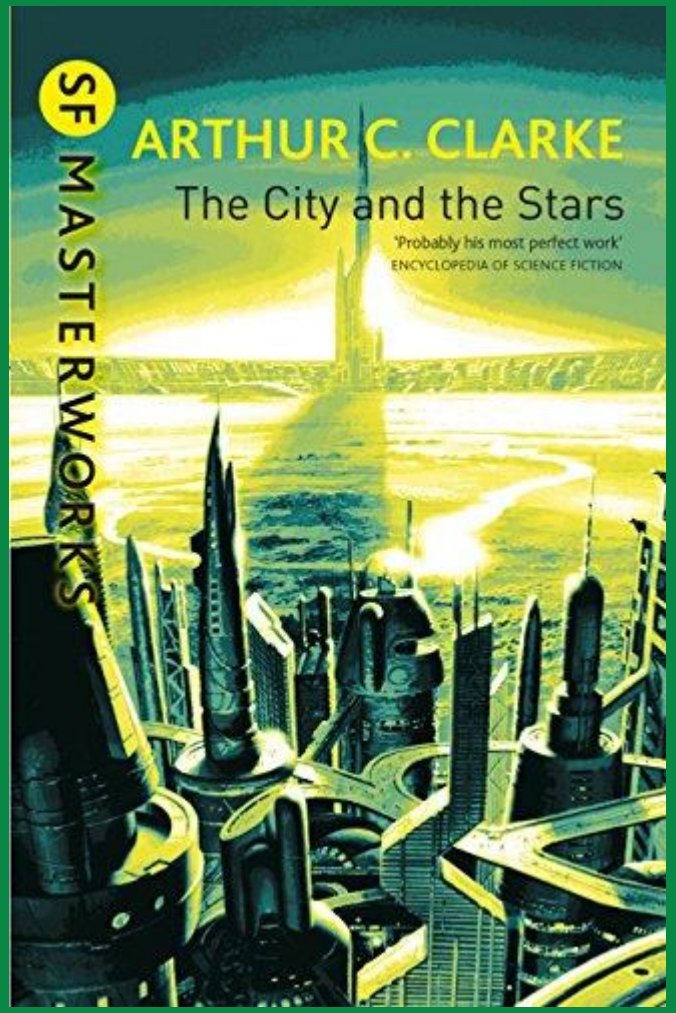
- Real-time, dynamic, multi-fidelity hybrid models of cyber-physical systems
- Real-time operation
- Advanced, adaptive control/decision-making. Can recommend interventions within a particular domain.
- Advanced spatio-temporal analytics and visualisation
- Advanced learning and data assimilation from multiple data sets

Digital Twin Maturity Levels

Level 4- Autonomous Decision Making

- Dynamic multi-scale, multi-domain, multi-system models - federated digital twins
- Real time operation
- High-level of autonomy – can perform most human operator functions, make interventions and take new courses of action autonomously
- State-of-the-art analytics and visualisation
- State-of-the-art AI/machine learning capability

Digital Twin Maturity Levels



"Men had built cities before, but never a city such as this. Some had lasted for centuries, some for millenniums, before Time had swept away even their names. Diaspar alone had challenged eternity, defending itself and all it sheltered against the slow attrition of the ages, the ravages of decay, and the corruption of rust"

Digital Twin Applications and Benefits

- Provides a representation of operational data
- Analysis of historical trends and potential causes for performance deterioration
- Support for decision making and optimisation of day-to-day operations
- Identify abnormal behaviour and reduce downtime
- Modelling future behavior based on analysis of operational parameters
- Predictive maintenance to minimise operational disruptions
- Agile decision making in response to changes and interventions
- Support for long-term strategic decisions to enhance efficiency, safety, reliability
- Identifies and recommends new interventions and actions
- Reduced dependence on human operators – enhanced safety

Thank you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