DEPARTMENT OF CIVIL, ENVIRONMENTAL AND GEOMATIC
ENGINEERING, UNIVERSITY COLLEGE LONDON

Digital twins in civil infrastructure

28th Jan 2022

EuroSDR workshop on Digital Twins for NMCAs and other governmental organisations

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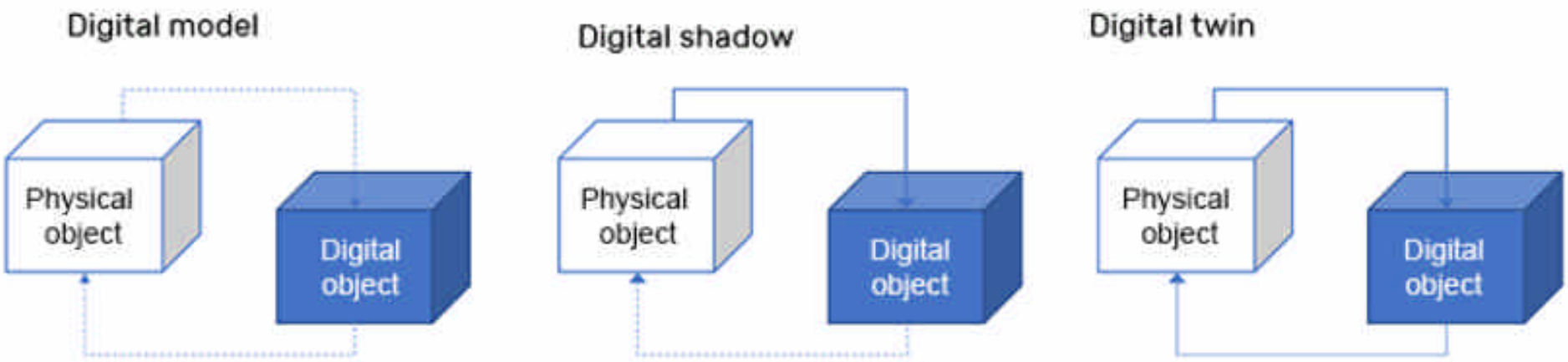
Digital Twins

"A realistic digital representation of existing assets, processes or systems in the built or natural environment, which is not a product, but an on-going process which continuously refines this representation.

A digital twin has a bi-directional connection to the real asset, process or system and contains a way of computationally analysing incoming information to generate valuable insights, for the purpose of one or more specific use-cases."

Digital ‘things’



Seppälä, L. Digital Model, Digital Shadow, or Digital Twin—What Is at the Core of Data-Driven Shipbuilding? 28 August 2020.

Scope – economic infrastructures

- Transport, energy, water, waste (water), telecoms, smart cities
- Physical networks: pipes, wires, rails
- Buildings: generators, stations, wind farms
- Systems: cyber-physical, digital, sensors, models
- Organisations and institutions: processes, structures, codes, regulations
- People: behaviours, demand, prosumers
- Supply chains: materials, people, knowledge
- Technologies: computing, machine learning, control rooms, SCADA, smart meters

sustainability

MDPI

Article

Digital Twins in Civil Infrastructure Systems

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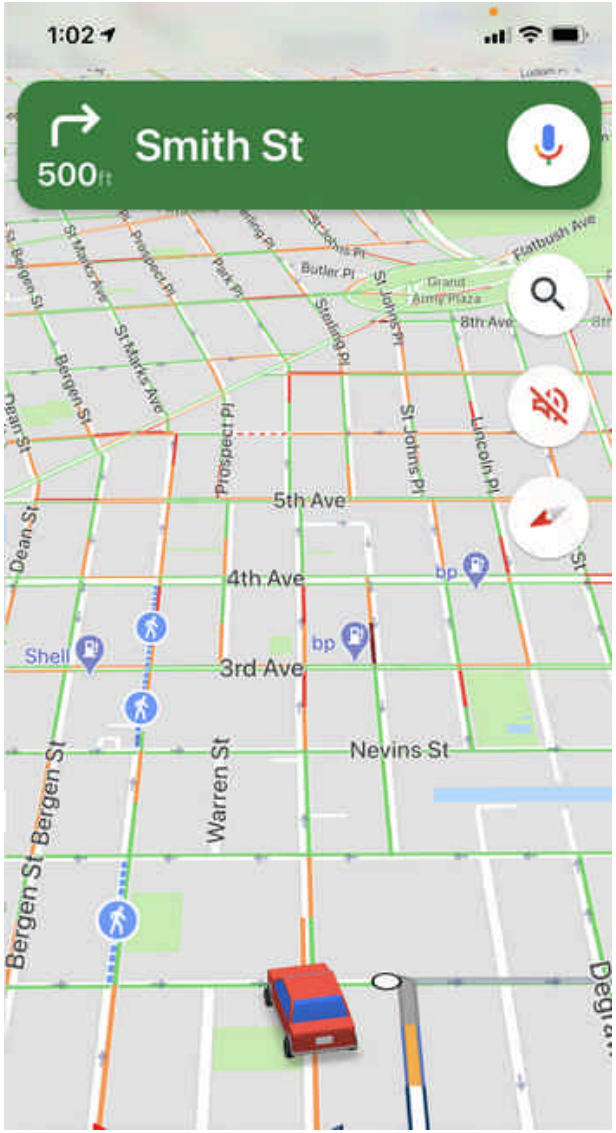
Use cases

Sector	Application	Use Case		
Water	[33]	Anomaly Detection	Demand Forecasting	Emergency Planning
		Maintenance Scheduling	Operational Optimisation	Predictive Maintenance
Energy	[34]	Predictive Maintenance		
	[35]	Anomaly Detection	Operational Optimisation	Service-life Forecasting
	[36]	Anomaly Detection	Operational Optimisation	Security Resilience
Rail	Alstom and AnyLogic [37]	Emergency Planning	Maintenance Scheduling	Timetable Optimisation
	Atkins and Etihad Rail [38]	Predictive Maintenance		
	Greater Anglia and Toshiba [39]	Anomaly Detection	Timetable Optimisation	
Highways and Autonomous Vehicles	Google Maps [40]	Operational Optimisation		
	Highways England [41]	Construction Process Optimisation		
	[42]	Route Forecasting		
	SAVe project, Germany [43]	Scenario modelling		
Bridges	[44]	Anomaly Detection	Service-life Forecasting	
	[45]	Anomaly Detection		
Smart Cities	Virtual Singapore [46]	Emergency Planning	Operational Optimisation	Planning Optimisation

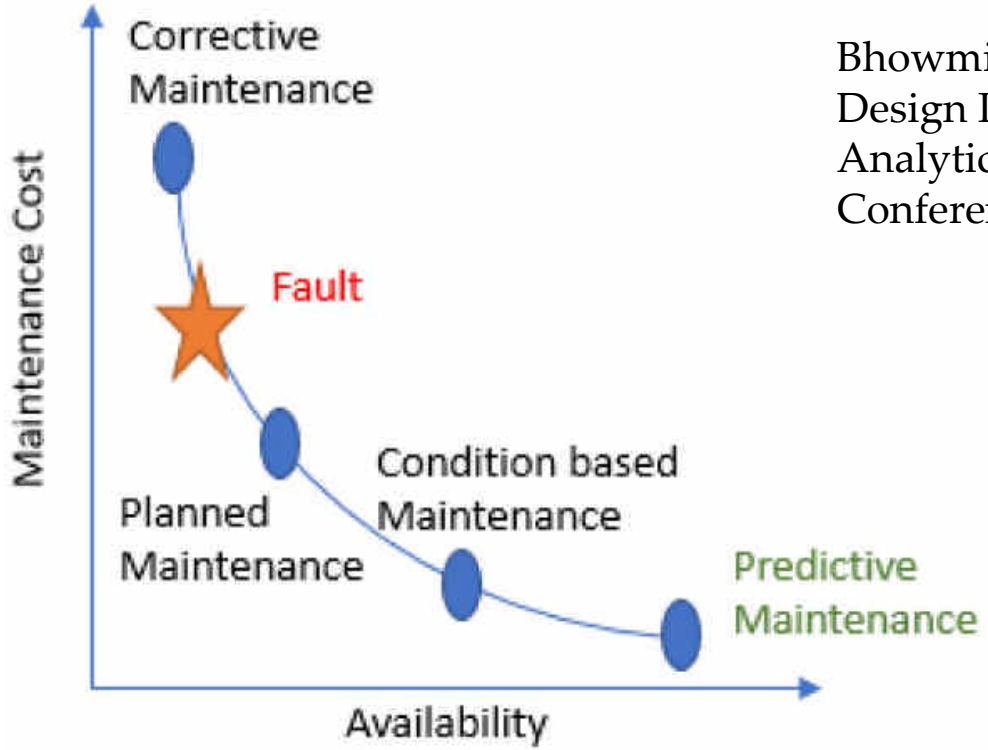
Route Forecasting

Google obtains traffic data anonymously from the real-time location data of smartphone users, in addition to local government traffic information and historical traffic data.

The insight and bi-directional connection come from the ability of Google Maps to compute the best route for a vehicle when there is traffic congestion ahead, thereby altering the physical asset itself.

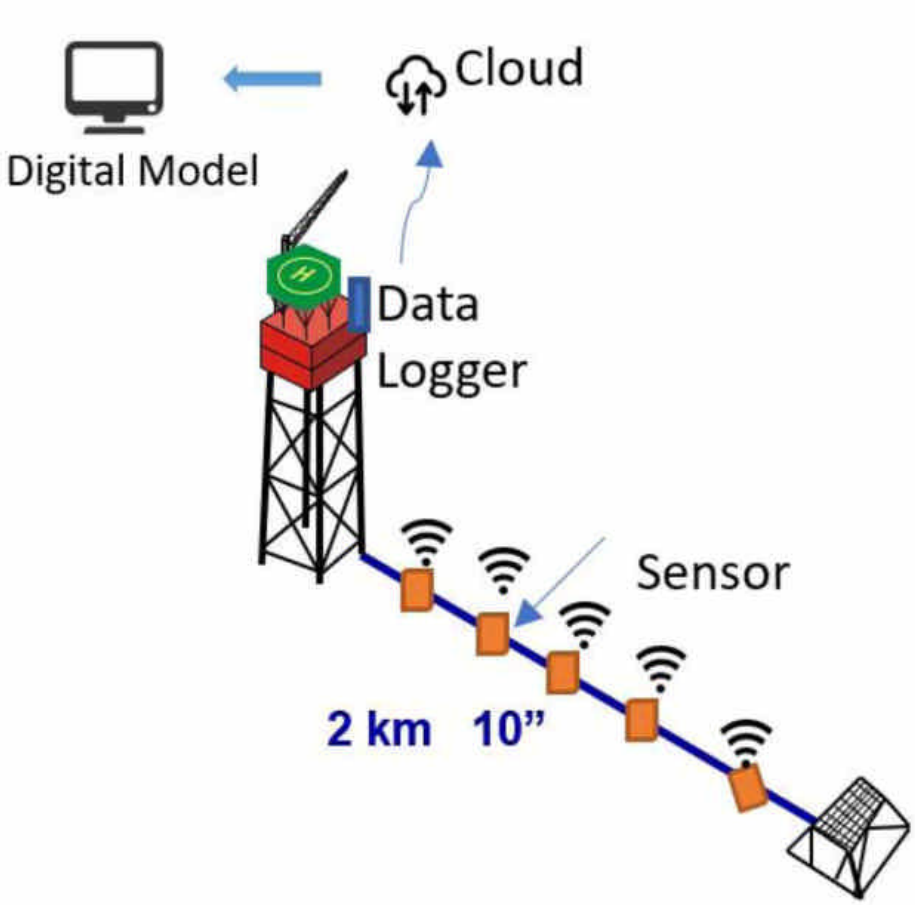


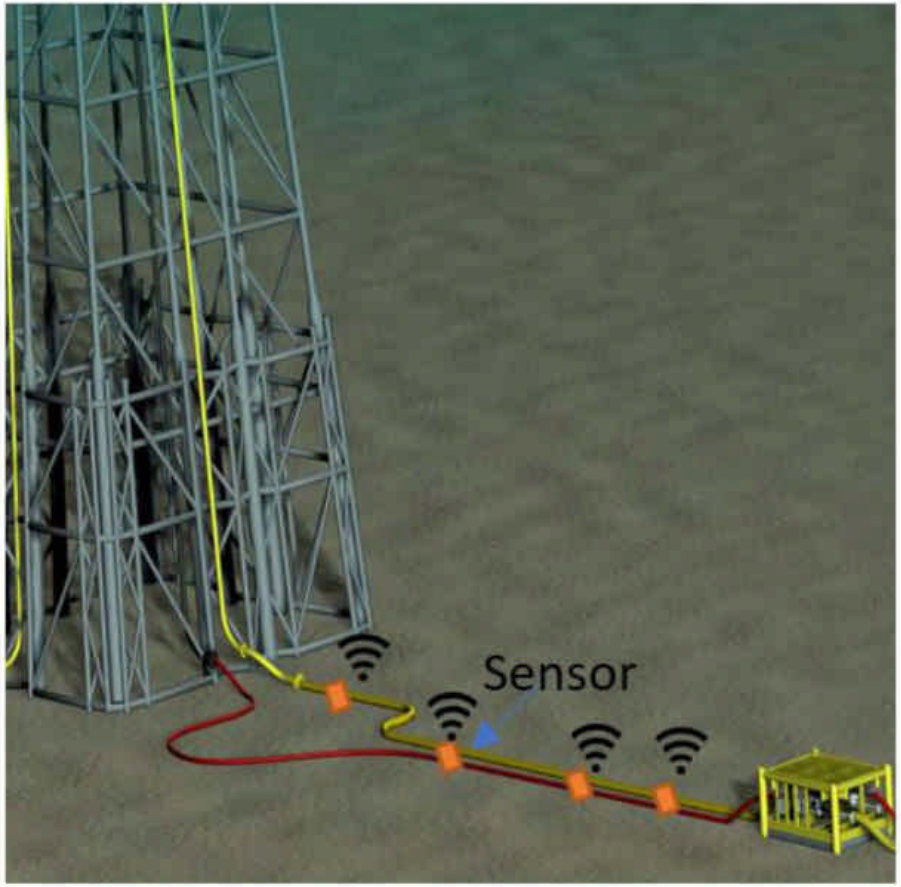
Predictive Maintenance



Bhowmik, S. Digital Twin of Subsea Pipelines: Conceptual Design Integrating IoT, Machine Learning and Data Analytics. In Proceedings of the Offshore Technology Conference, Houston, TX, USA, 6–9 May 2019

Digital Twin process – subsea pipeline





Survey vs literature

	Digital Twins of Real Systems	Human Input	Regulation and Governance	Data Challenges and Quality Control
Smart Cities	Literature & survey agree that DTs can be predictive models of real processes and systems	Strong agreement in literature & survey on human input. Strong emphasis on Smart City development	Strong agreement in literature & survey on decentralised preference	Strong agreement in literature and survey on major challenges being data security, privacy and quality
Energy	Literature & survey agree that DTs can be predictive models	Literature & survey agree that humans can be part of the loop. Literature explores automation.	Common standards for DTs considered important in survey but not in literature	Trust and quality of data assumed to be easy in survey but not in literature
Transport	Literature & survey agree that DTs must have computational intelligence	Literature & survey agree that humans can be part of the loop. Literature explores automation.	Centralised governance prefered in literature but not in survey	Trust and quality of data is important in survey and literature
Water	Predictive model is considered a DT by survey and not by literature	Literature & survey agree that humans can be part of the loop. Literature explores automation.	Developing a consensus definition considered easy in survey but not in literature	Securing continued access to data by all parties considered important in both
Waste Management & Telecom	Literature agrees that DTs can be predictive models	Literature agrees that humans can be part of the loop and explores automation.	Inconclusive	Trust and quality of data important in literature

Next steps

1. Definition refinement
2. Collaborative development of a structure of how to implement DTs more effectively
3. Quantification of uncertainties for DTs
4. Focus on shorter temporal scale to increase certainty and high value use cases where safety risks or access limitations are involved
5. Testing retrofit into existing infrastructure
6. Accessible yet still highly secure data sharing between interconnected DTs.
7. Increase the digital maturity of the workforce
8. An organisation should be created to oversee all government-funded projects related to DTs.

International Circular Economy Centre for Mineral Based Construction Materials

Three case studies with digital twins to quantify how circular economy approaches and eco-design principles reduce environmental impact

EPSRC
Engineering and Physical Sciences Research Council

CE-HUB
UKRI National Interdisciplinary Circular Economy Research

1. Autonomous shipping
2. Linear freight movement
3. Road tunnel under the Thames

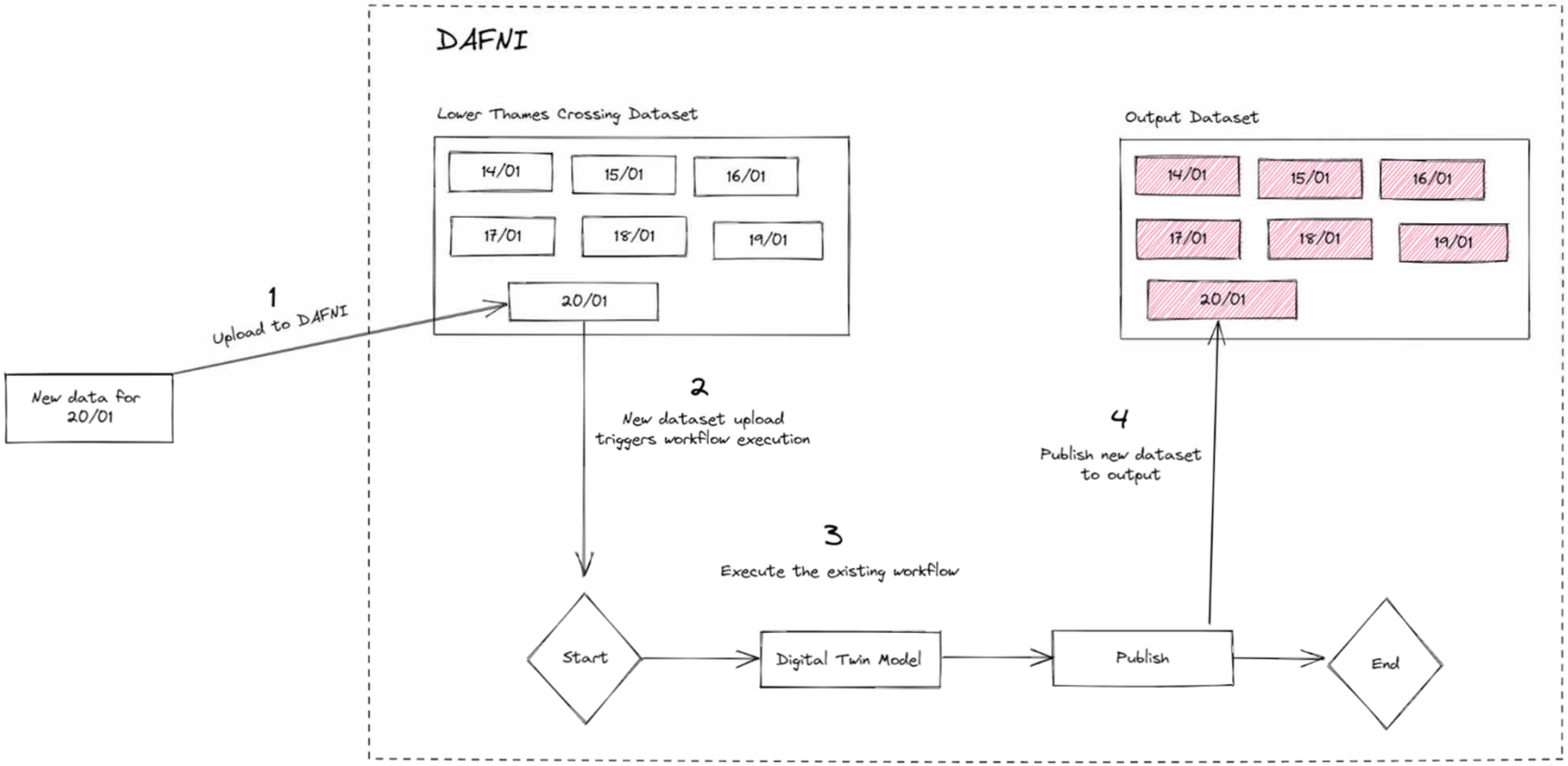
https://www.ucl.ac.uk/circular-economy-centre-for-construction-minerals/research/challenge-3-systemic-enablers-mcm-circularity/focus-area-3b-eco-design

Autonomous shipping

- Use case – net zero freight movement
- Digital Twin – to direct speed and course, reduce wait time

https://www.gard.no/web/updates/content/32513672/the-third-pillar-a-contractual-architecture-for-maritime-decarbonisation

Draft DAFNI workflow integration



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