The holistic digital-first systems approach

Professor Jennifer Whyte
Director, John Grill Institute for Project Leadership

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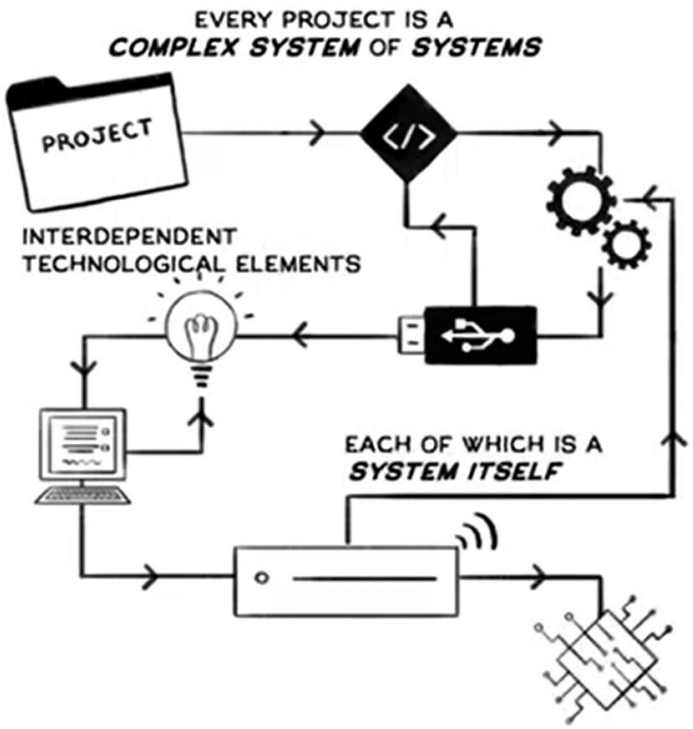
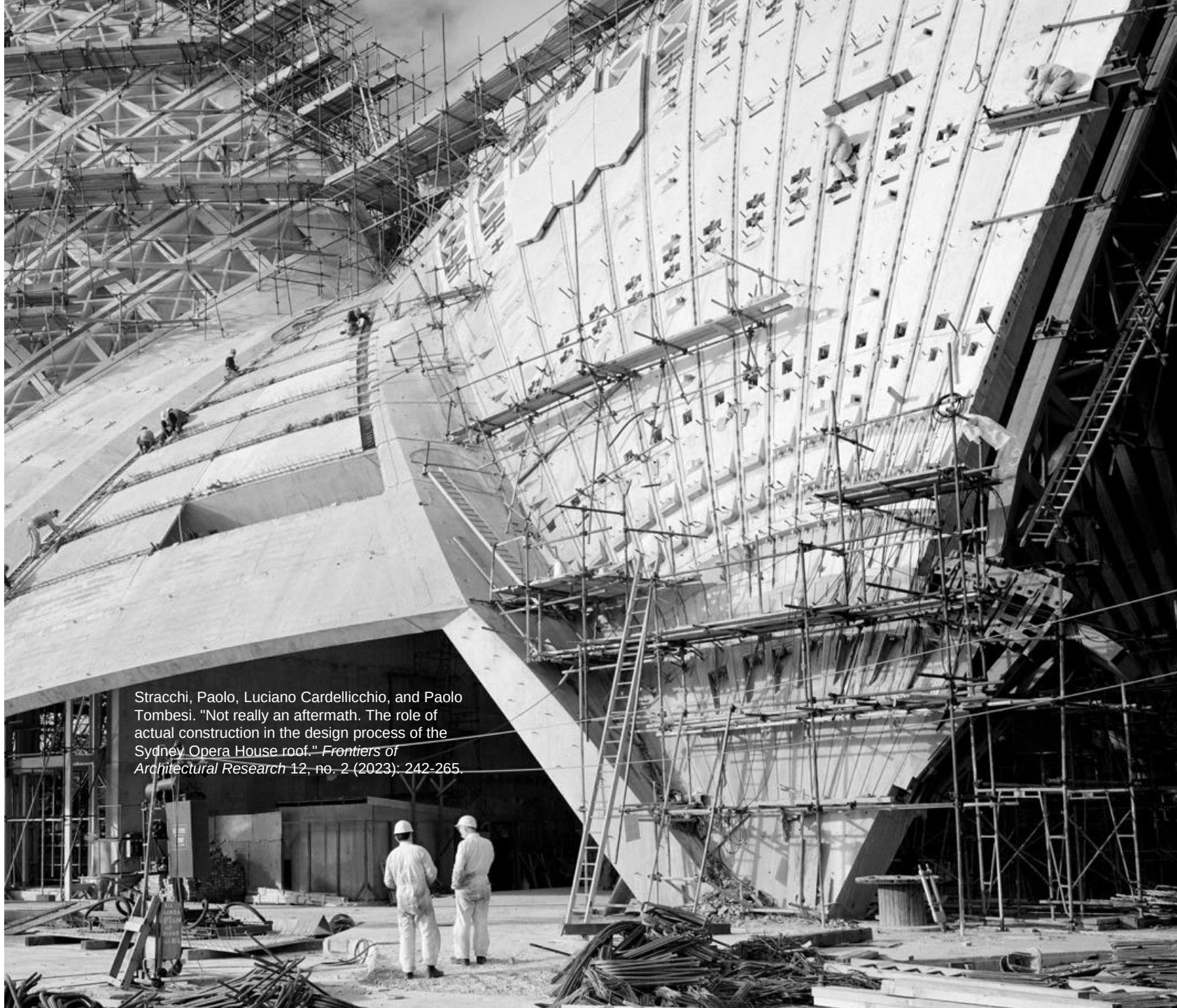


Complex organisationally:

- Architects
- Engineers
- Builders / Contractors
- Sub-contractors
- Manufacturers, etc.

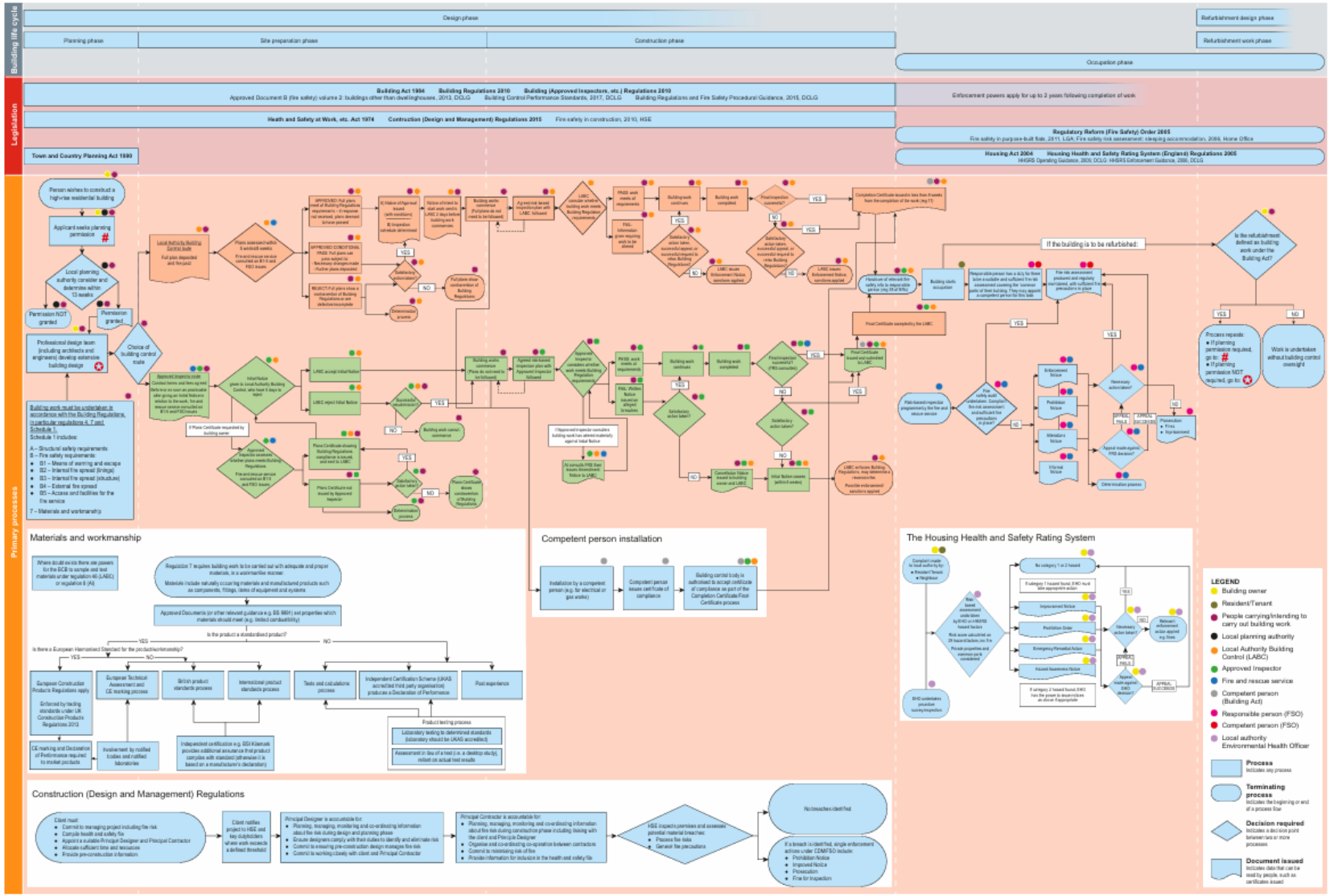
What can digital improve?



Stracchi, Paolo, Luciano Cardellicchio, and Paolo Tombesi. "Not really an aftermath. The role of actual construction in the design process of the Sydney Opera House roof." *Frontiers of Architectural Research* 12, no. 2 (2023): 242-265.

Photo by the blowup on Unsplash

Mapping the building and fire safety regulatory system – high-rise residential buildings



Hackitt, J. (2017) Building a Safer Future, Independent Review of Building Regulations and Fire Safety, Interim Report, UK --- need for a 'golden thread' of information.

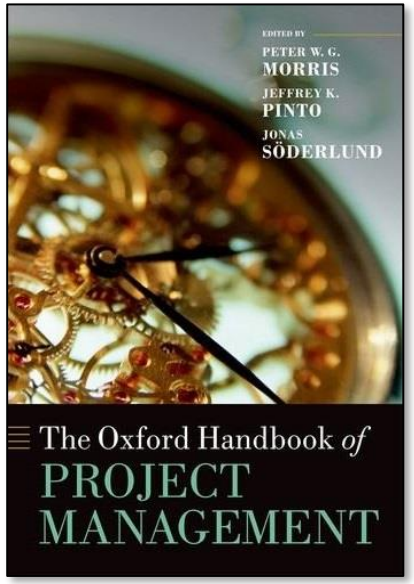
Overview

- Growth in computing power
- Transforming construction (policy)
- Digital buildings and infrastructure (research)
- Systems approach

Growth in Computing Power

Table 15.1 Time-line of technologies and techniques in use on major projects

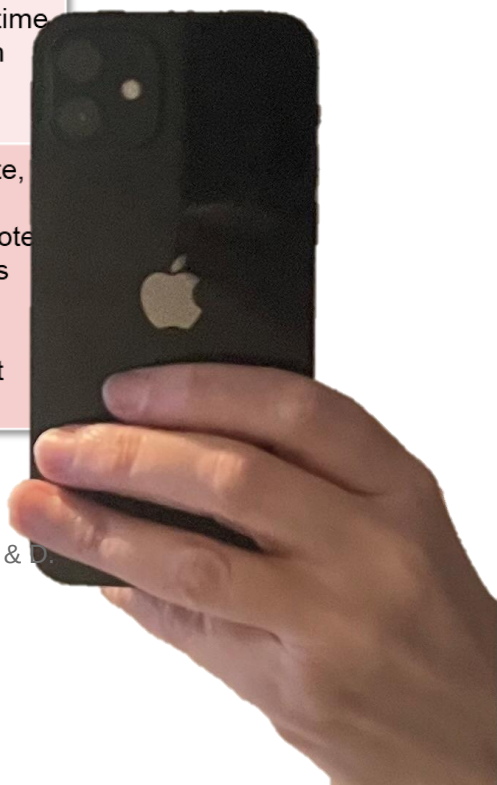
	1950s	1960s	1970s	1980s	1990s	2000s
Hardware	Mainframe batch computing e.g. Whirlwind	High-end real-time e.g. DAC-1; PERT	Bitmapped screens; computer graphics	First personal computers	Laptops, internet, and first mobile computing	Mobile computing, sensors, electronic paper
Software	Automated engineering analysis tools e.g. STRUDL	Database Management Systems; e.g. ICES, IDMS	Standards, protocols and processes, e.g. IDEF0; CMM	PC-based CAD and project management; simulation; internet	Automated digital search; expert systems; project extranets	Visual decision-making tools; shared workspaces
New Capabilities	Automate analysis	Automate scheduling, accounting; share data	Text processing; widespread engineering automation; sharing of information	Diffusion of computers to smaller firms and individuals; knowledge formalization	Share information and knowledge across teams and firms	Agile, decentralized development methods using centralized data storage and applications



Whyte, J., & Levitt, R. (2011). Information management and the management of projects (Chapter 15). In *The Oxford Handbook of Project Management*. Oxford University Press.

Growth in Computing Power

	1970s	1980s	1990s	2000s	2010s	2020s
Hardware	Bitmapped screens; computer graphics	First personal computers	Laptops, Internet, and first mobile computing	Mobile computing, sensors, electronic paper	Smartphone; 3D printers; point clouds scanners; sensors; 3G evolution	Control rooms; autonomous robots; drones
Software	Standards, protocols, and processes, e.g., IDEF0; CMM	PC-based CAD and project management; simulation; Internet	Automated digital search; expert systems; project extranets	Visual decision-making tools; shared workspaces	Semantic Web and linked data, data mining, and machine learning tools and techniques	Platforms; digital twin; streaming and integrating real-time data; blockchain
New capabilities	Text processing; widespread engineering automation; sharing of information	Diffusion of computers to smaller firms and individuals; knowledge formalisation	Share information and knowledge across teams and firms	Agile, decentralised development methods Using centralised data storage and applications	Data analytics and data mining, instant communications, managing cyber-physical systems, simulation of process and product	Extensive remote, and hybrid (in-person and remote working, insights definition, data-driven decision-making, resilient platforms



Whyte, J., Farghaly, K., & Zhou, A. (2023). The digital revolution and complex project organizing: Towards project management (PM) 4.0? In G. Winch, M. Brunet, & D. Cao (Eds.), *Research Handbook on Complex Project Organizing*. Edward Elgar Research Handbooks in Business and Management, Edward Elgar Publishers.

Growth in Computing Power

- Devices are becoming cheaper, more distributed and more multi-functional
- Increasing in data availability and use
- Potentially wide-reaching implications for design, delivery, operation, and maintenance (increasing integration)
- Digital thread, model, twin, platform, analytics?

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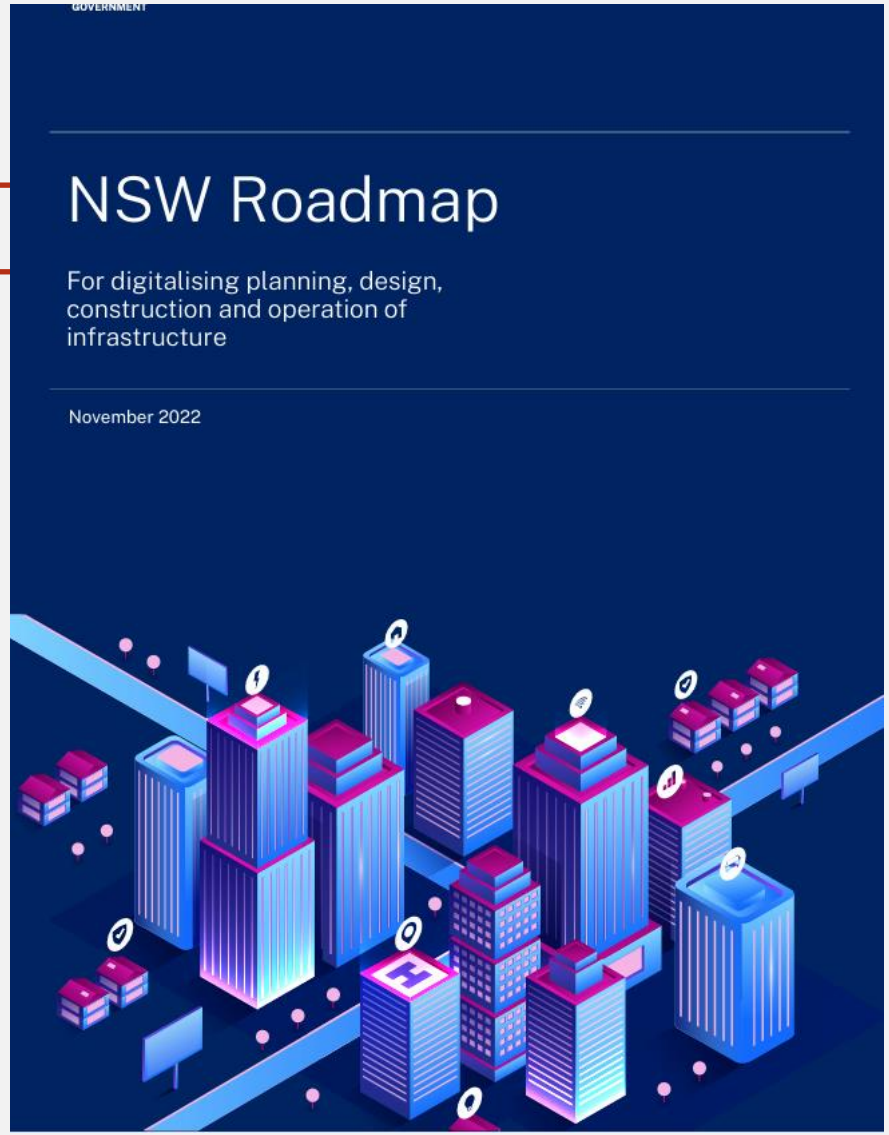


UK experience:

- **Digital as part of transforming construction**
- **Presumption in favour of offsite construction**

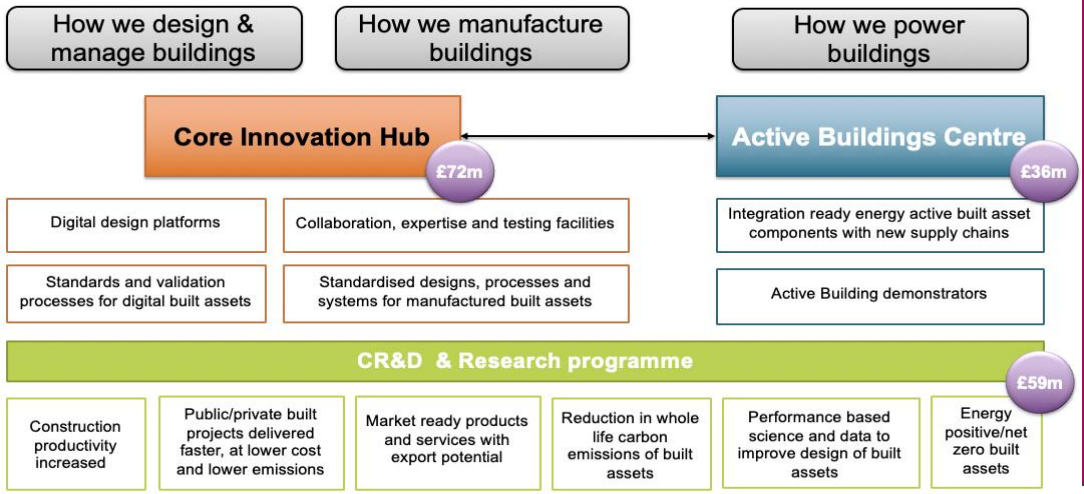
Transforming Construction Challenge Network +

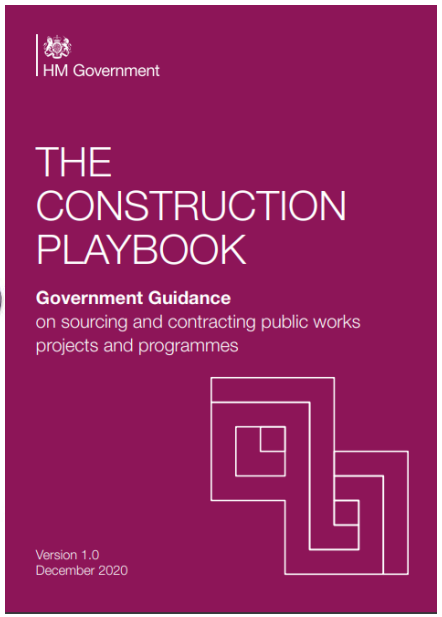
construction **manufacturing** **energy** **digital**

TRANSFORMING CONSTRUCTION NETWORK PLUS

UCL Imperial College London WMG THE UNIVERSITY OF WARWICK

FUNDED BY UK Research and Innovation





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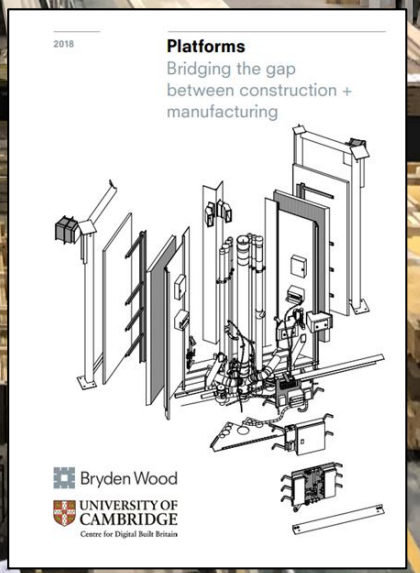

HTA Architects

Bryden Wood

What are Product Platforms?

Product Platforms are an integrated approach to commonality and variability across multiple projects, providing the benefits of manufactured approaches while catering for the project-specific needs of clients and users of buildings. They are well adopted in other industries as a means of delivering mass customization: offering customer choice and high quality at near mass-produced prices.

Product Platforms span design, production, commercial and use, and comprise:

Standardised repeatable components

- A kit of parts which are digitally designed and can be configured and combined with complementary, bespoke elements within a defined technical framework to produce customised buildings (or parts of buildings) that enable improved outcomes, best-value procurement and efficient delivery

Standardised repeatable processes

- A suite of repeatable processes that de-risk design and business case development through optimising best practice

People and relationships

- Longer-term and strategic relationships based on defined technical and commercial interfaces which allow innovation to take place at multiple levels of the supply chain and continuously improve, driving economies of repetition

They can deliver social infrastructure facilities 30% cheaper

Design	Fast-track development and approval using tried and tested solutions	Continuous value management through the delivery process
	Robust, adaptable designs based on data and feedback	
Materials	Increased value in decarbonisation investments due to pipeline of demand	Reduced waste and over-ordering
		Improved forecasting due to reduced volatility and variability of demand
Manufacture	Reduced variability in components, enabling higher utilisation of capital	Repeatable solutions enabling procurement at scale
	Enables increased investment due to repetition and continuity	
Assembly	Mitigate delivery risks by simplifying processes and increasing certainty	Manufactured solutions with pre-engineered interfaces and improved tolerances

https://www.constructioninnovationhub.org.uk/media/b3sfkkaz/the-value-of-platforms-final-april-2023.pdf

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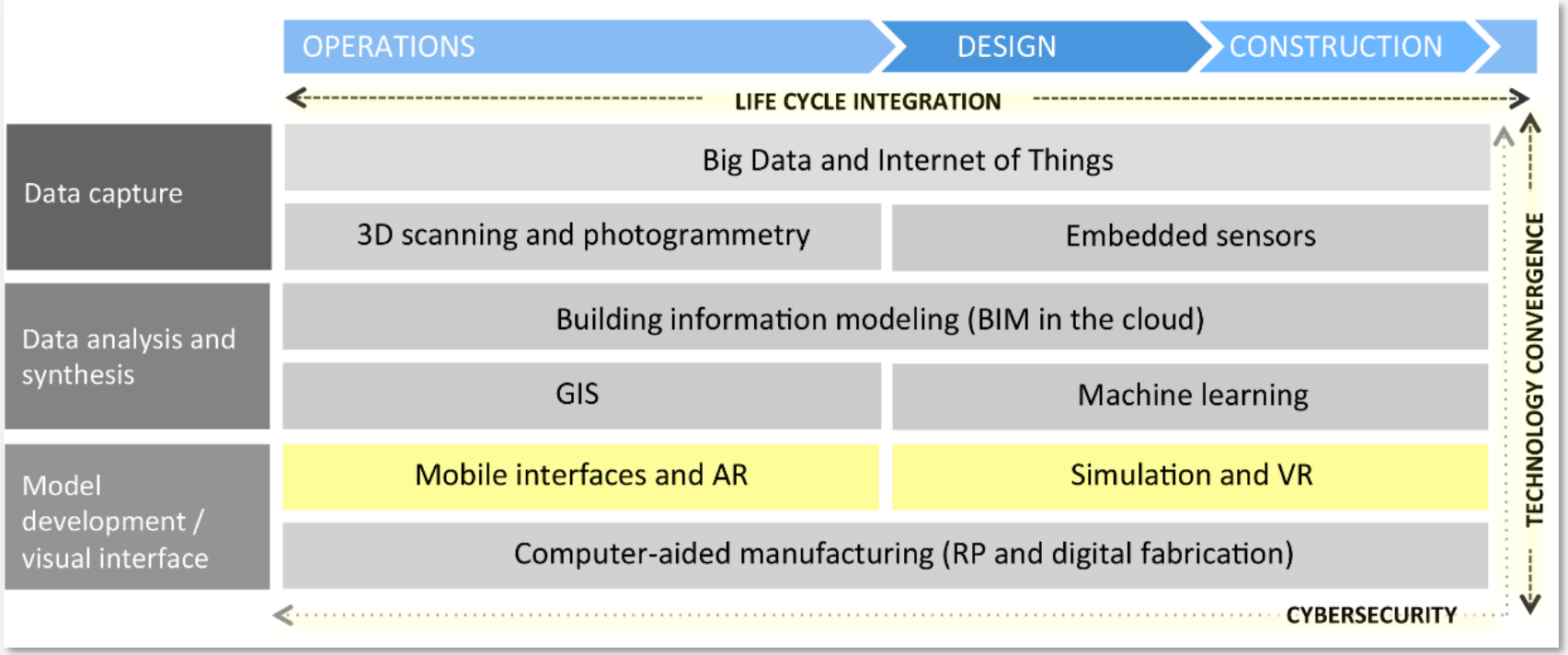
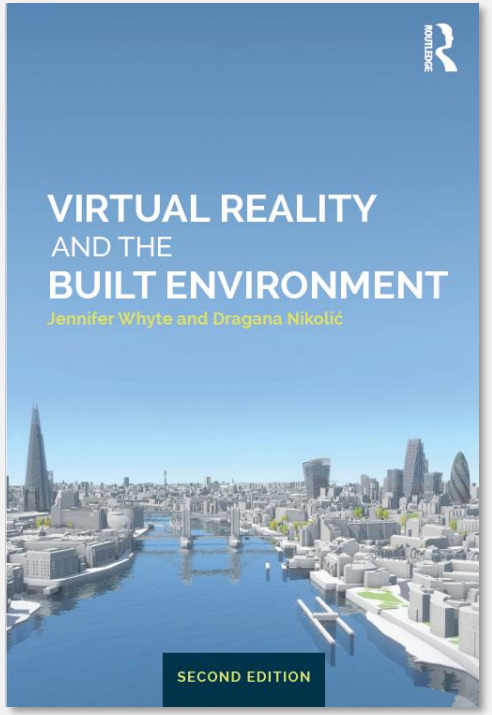
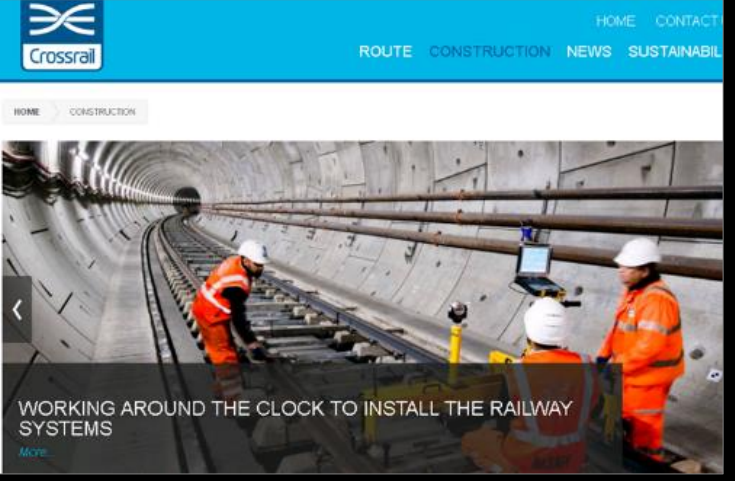


Fig 2-14: Integration of digital technologies across the design, construction, and operation fields (Source: adapted from Gerbert et al., 2016)



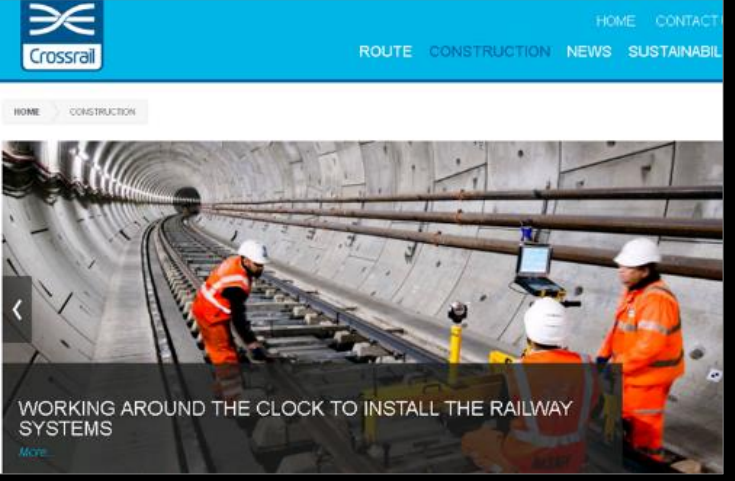
Virtual Reality and the Built Environment:
Jennifer Whyte and Dragana Nikolić, ©2018



Elizabeth Line, (Crossrail, £14.8bn+ (26.8bn+ AUD)

Crossrail Site from Webcam

Photo by Kevin Grieve on Unsplash



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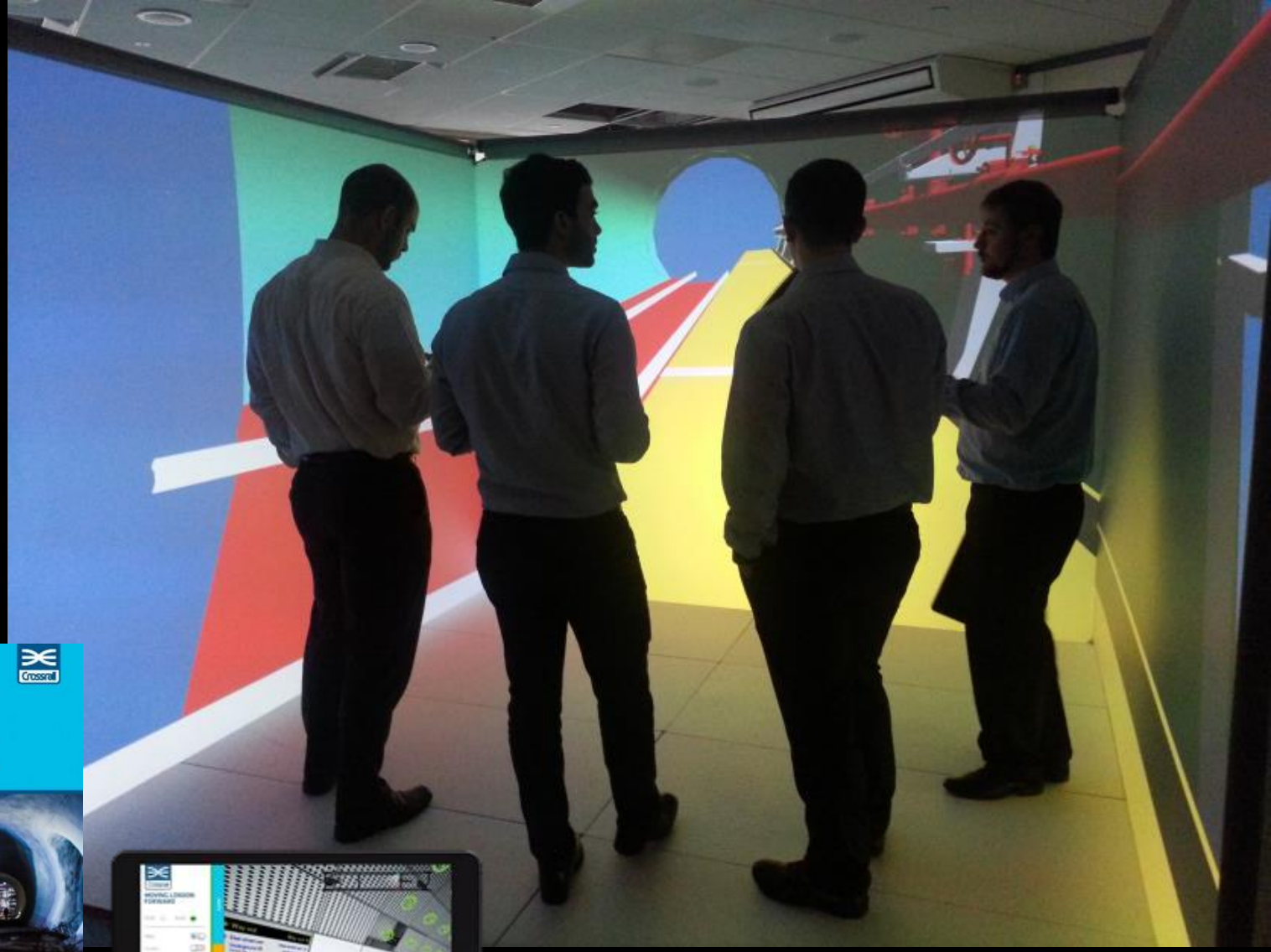
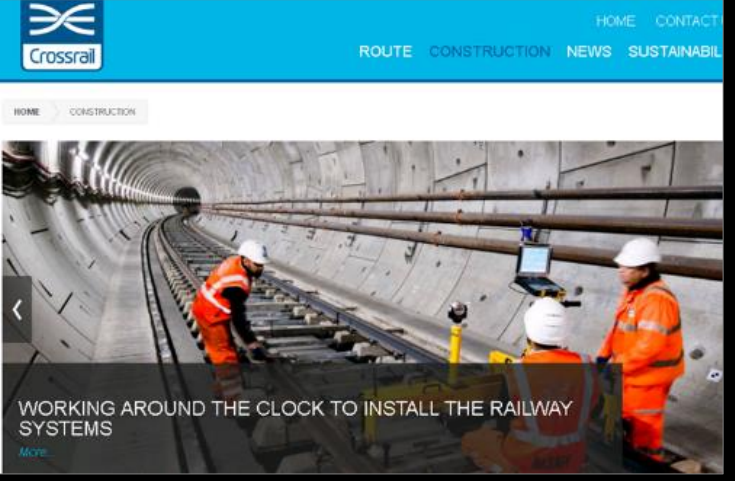


Nikolic, D., Maftei, L., & Whyte, J. (2019). Becoming familiar: how infrastructure engineers begin to use collaborative virtual reality in their interdisciplinary practice. *Journal of Information Technology in Construction*, *24*, 489-508. https://doi.org/10.36680/j.itcon.2019.026



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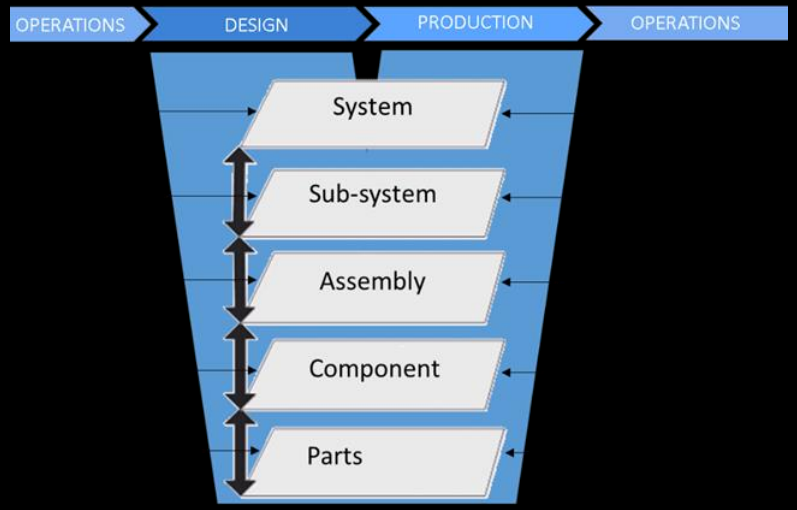

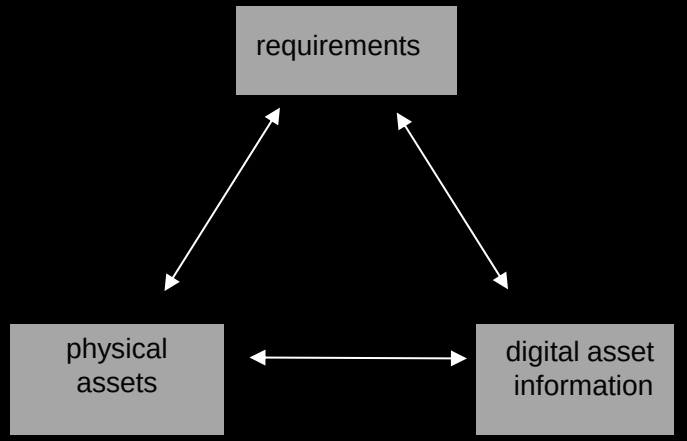

Whyte, J., Stasis, A. and Lindkvist, C. (2016) Managing change in complex projects: configuration management; asset information and big data. International Journal of Project Management, 34, 2, 339–351

Whyte, J., & Davies, A. (2021). Reframing Systems Integration: A Process Perspective on Projects. Project Management Journal, 52(3), 237–249. https://doi.org/10.1177/8756972821992246

John Grill Institute for Project Leadership

Mission: To Improve Project Leadership

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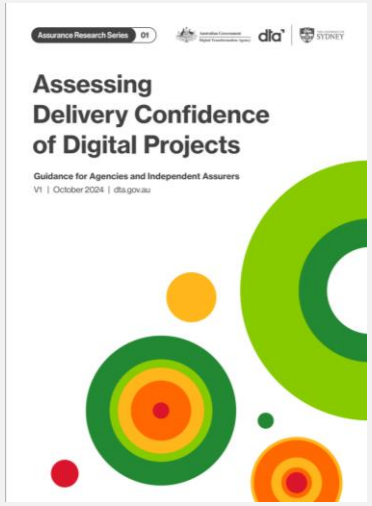

[Major Projects Leadership Forum - Reform Roadmap - JGIPL]

Value of industry, policy and research collaboration

Home / Research / Digital Transformation

In today's fast-paced environment, complex projects require more than traditional methods. We look into integrating digital transformation into every aspect of project management — from AI methods for project delivery and governance, to digital transformation by projects, and how digital information transforms the project model.

1. New AI methods for project delivery and governance +
2. Digital transformation by projects +
3. How digital information transforms the project model +

Our researchers draw on expertise across the University of Sydney, including computer science, data science and medicine, to understand areas of application such as asset management and mega projects.

We offer customised collaborative frameworks, such as competitive grants, to ensure efficient engagements and meet your needs.

"As the computational devices used in all aspects of project delivery are becoming progressively smaller and cheaper, digital information is changing what projects deliver, with information becoming itself a deliverable." – Whyte, 2019

Research

Journal Articles | Other Research Outputs

AI for Management and Organization Research: Examples and Reflections from Project Studies

A data-driven conceptual framework for understanding the nature of hazards in railway accidents

Experts

Dr Jin Xue
Academic Lead

Dr Wei-Ting (Kevin) Hong
Research Lead

Professor Michael Bell

Professor Jinman Kim

Overview

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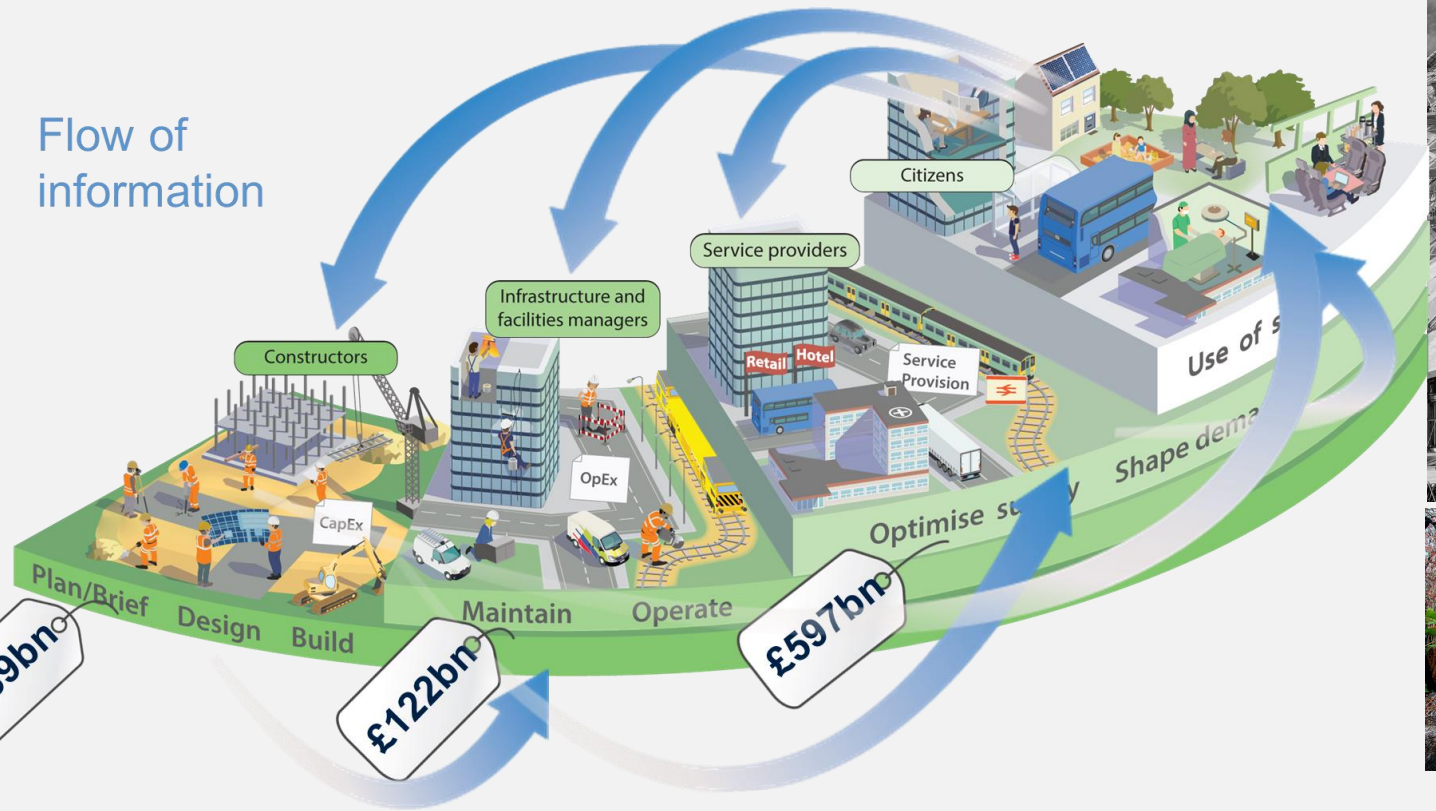
A holistic digital-first systems approach

- Digital information for making choices and managing risk in building futures



The holistic digital-first systems approach

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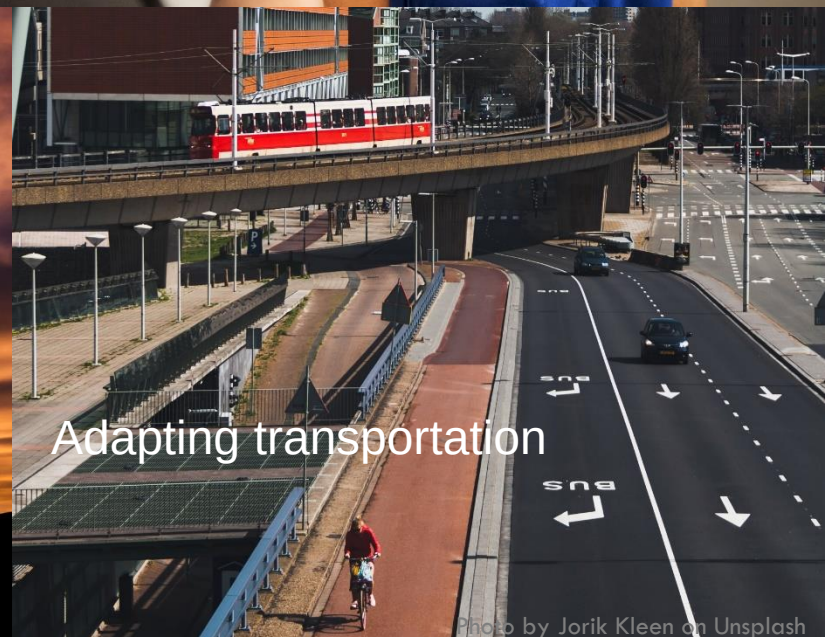
Projects are future-oriented



Futures are uncertain

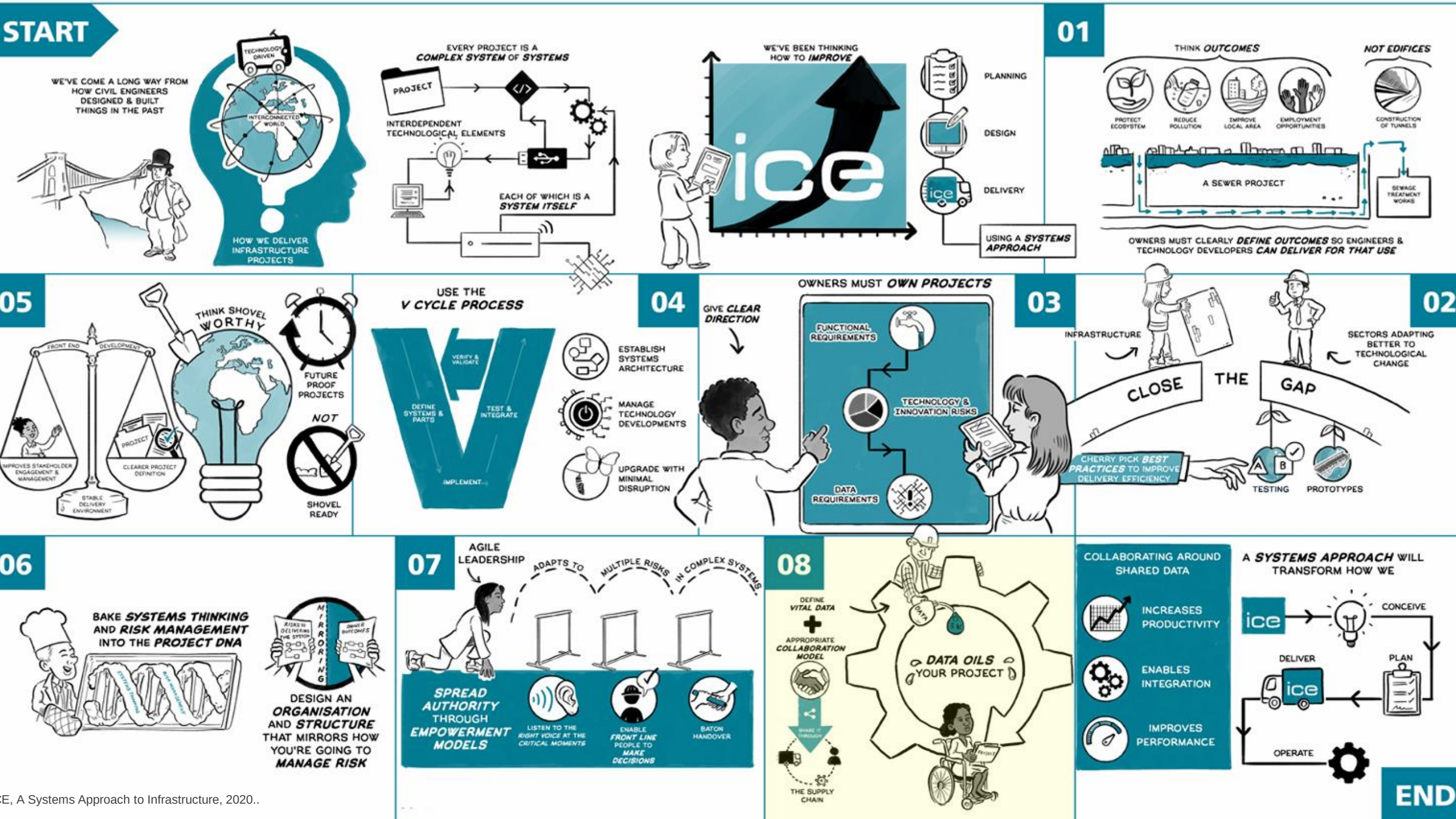
Information Use in Temporary Organizations

As in more permanent organizations, temporary organizations:

1. Access digital information through information systems provided by global software companies, and
2. Structure that information using standardized forms and workflows.

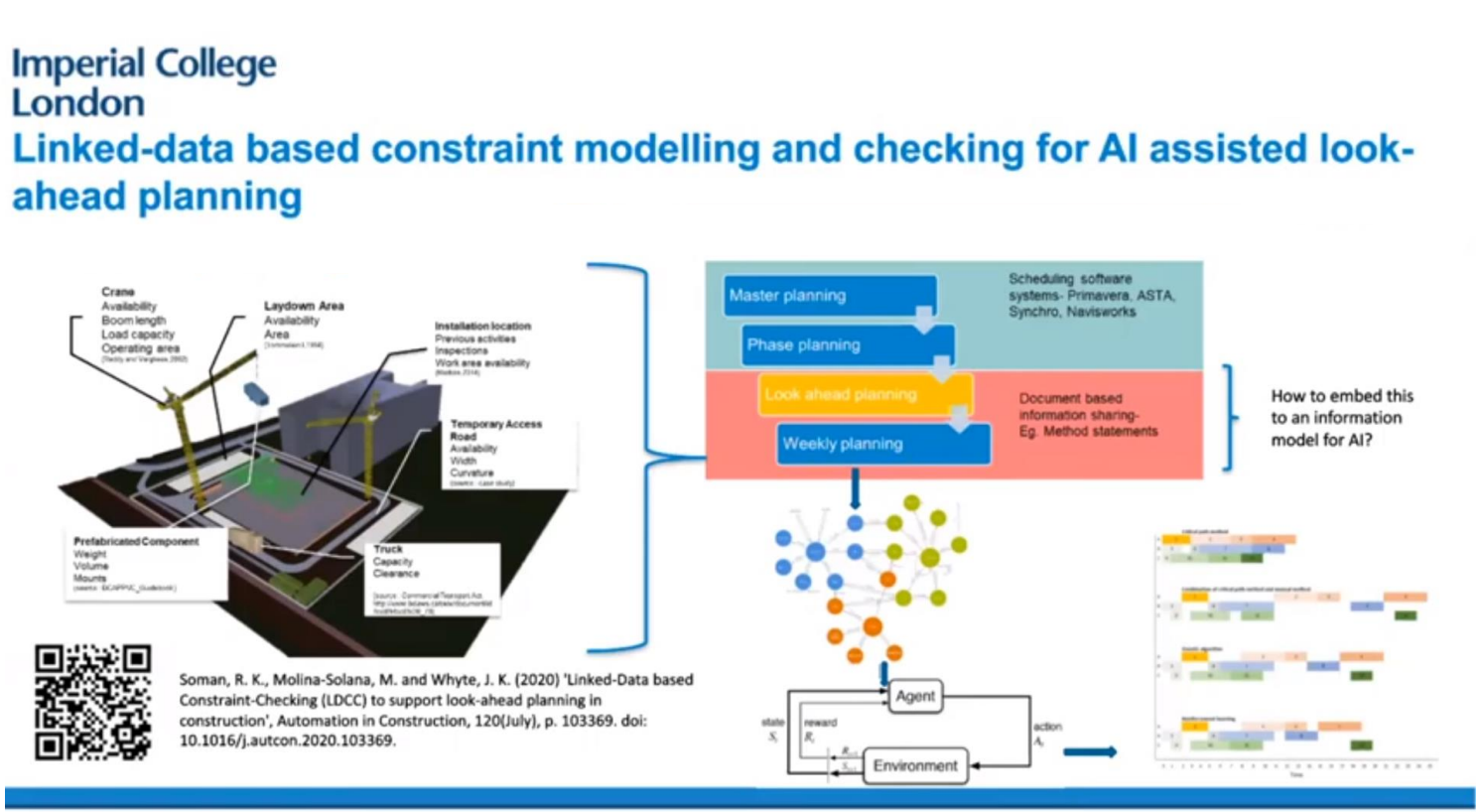
Yet, two salient and distinctive features of digital information in temporary organizations are:

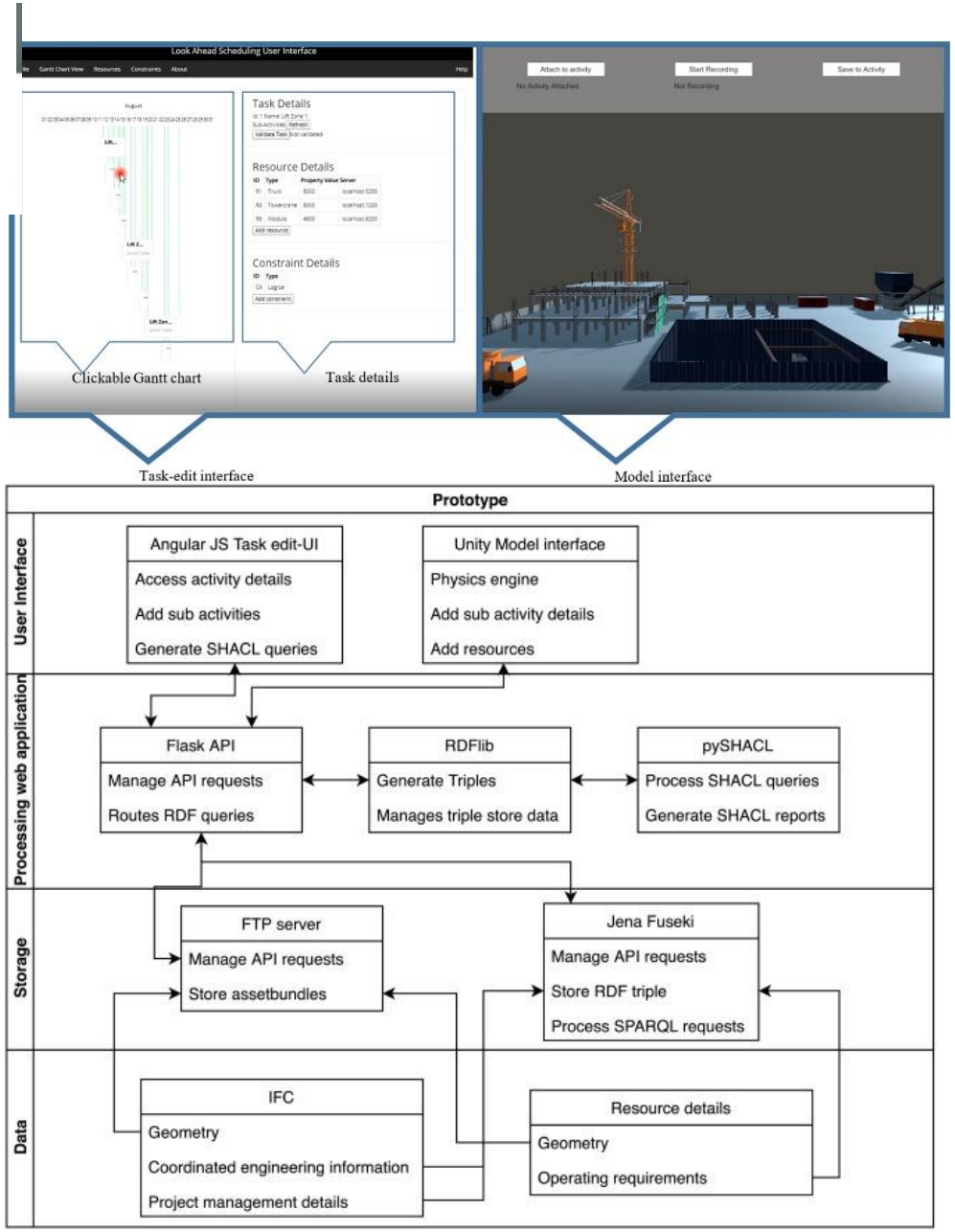
1. Diverse types of digital information pre-exist before, are generated in and persist after temporary organizing;
2. Digital information is not located in an information system but rather transferred and used across multiple systems in the processes of organizing and as an output of organizing.



CE, A Systems Approach to Infrastructure, 2020..

Example of PhD work: **AI and Project Scheduling**



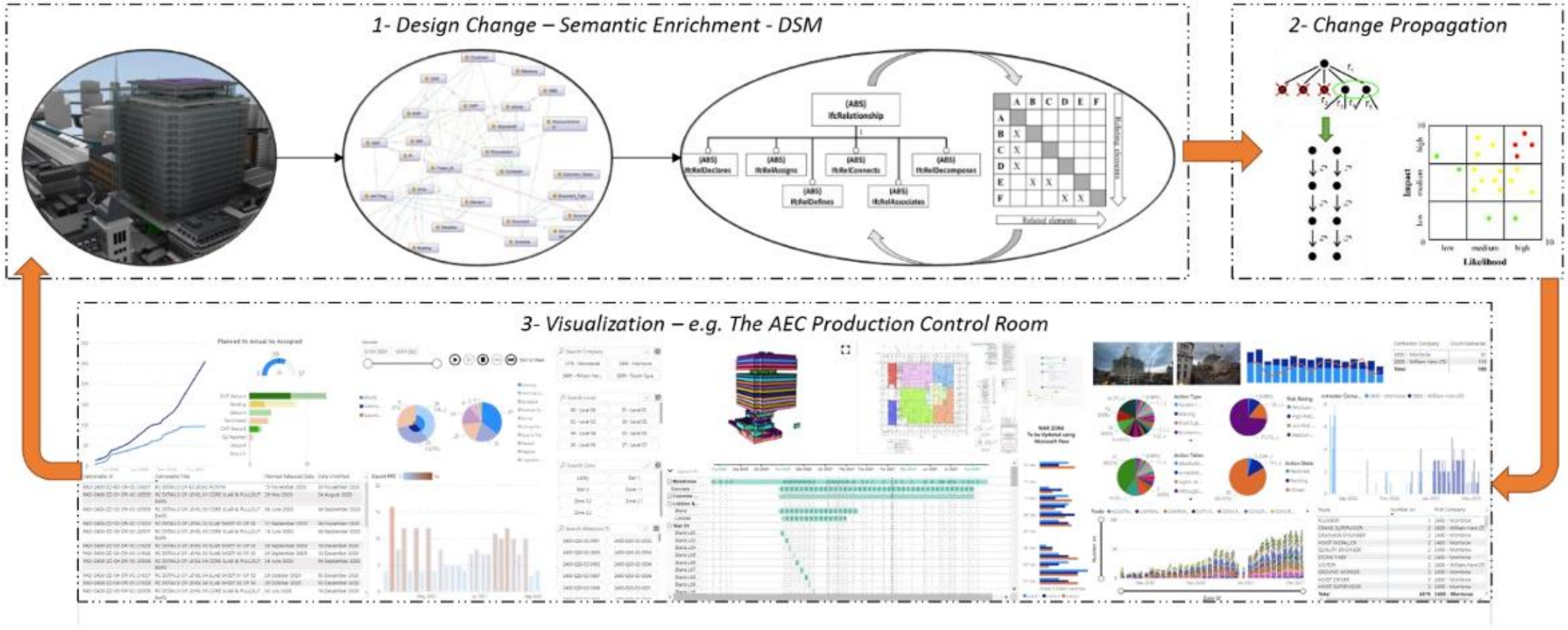


PhD Project 2017-2020 – Dr Ranjith Soman (particular focus on constraints modelling for 6-week site look-ahead)

co-supervised
Whyte (**civil engineering**) and Molina-Solana (**computer science**), with industry partner **Bentley Systems**

Soman: postdoc Imperial 2020-1, ETH Zurich 2021-2, lecturer TU Delft 2023

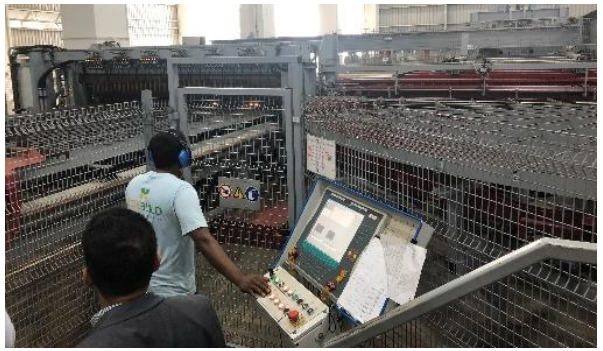
Digitally-enabled systems integration



Design change, change propagation and the visualisation

Chen, L. & Whyte, J. (2022) Understanding design: change propagation in complex engineering systesm using a digital twin and design structure matrix, *Engineering Construction and Architectural Management*, 29(8) 2950-75.
Soman, R.K., Molina-Solana, M.: Automating look-ahead schedule generation for construction using linked-data based constraint checking and reinforcement learning. Automation in Construction 134, 104069 (2022)
Farghaly, K., Soman, R.K., Whyte, J.: Visualizing real-time information through a construction production control room. In: EC3 Conference 2021, pp. 415-422. ETH, (2021)
Farghaly, K., Soman, R., & Whyte, J.: cSite ontology for production control of construction sites. Automation in Construction, 158, 105224. (2024)

Singapore

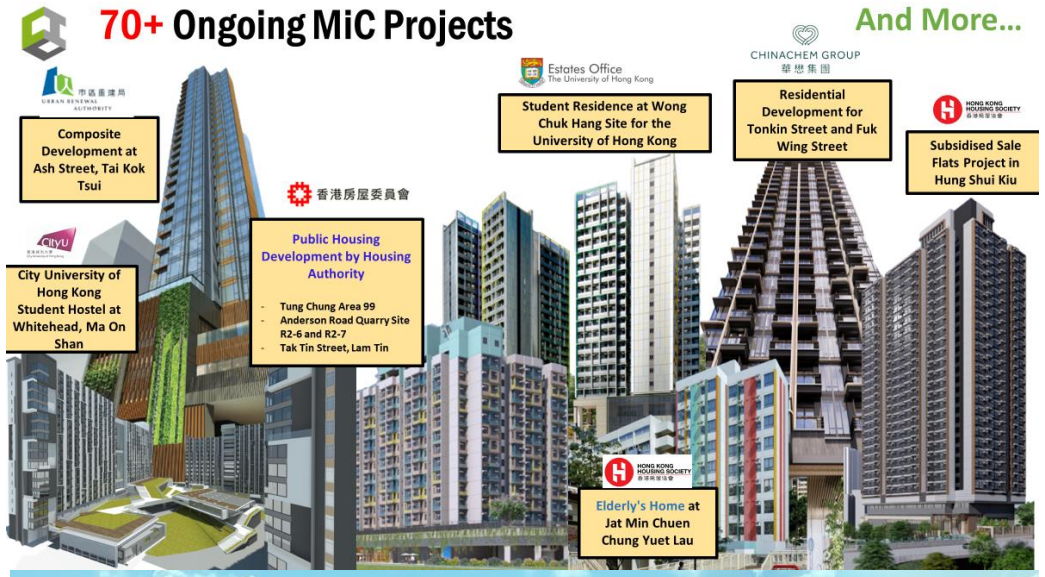


Context	Case study firm	Modularization success through …	External competences	
			Availability	Firms' actions achieving reliability
Mainland China	Alpha	Building internal competences	Not available	
Hong Kong	Beta	Using external manufacturing and assembly competences	Available	Reliability of competences achieved through the use of standards, monitoring and product control
Singapore	Gamma	Seeking to use external competences, then building internally	Available	Reliability not achieved and competences brought in-house

In each context, the case firm developed modularization strategies successfully through using internal competences, or using external competences subject to availability and reliability of such competences

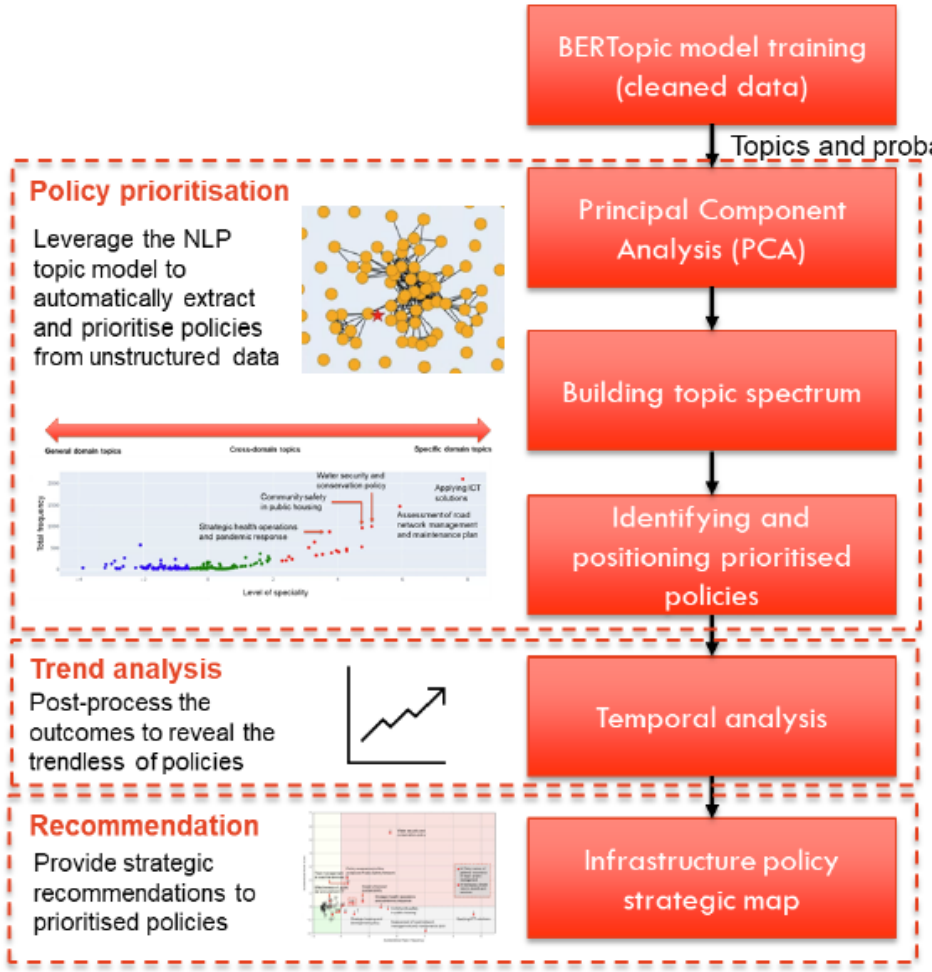
Zhou, S., Mosca, L., & Whyte, J. (2023). How the reliability of external competences shapes the modularization strategies of industrialized construction firms. *Construction Management and Economics*, 1-12.

Hong Kong



https://experience.arcgis.com/experience/7bfaa8d6b15c43dab033a3d5456e052c/

Project Analytics: NLP application



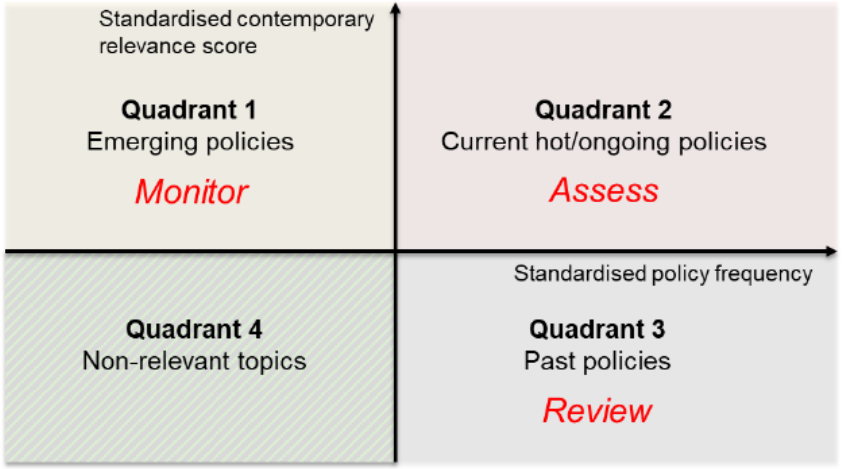
3.1 Topic modelling – BERTopic
Building a BERTopic model at the sentence-level analysis to extract policies and contextual insights from documents.

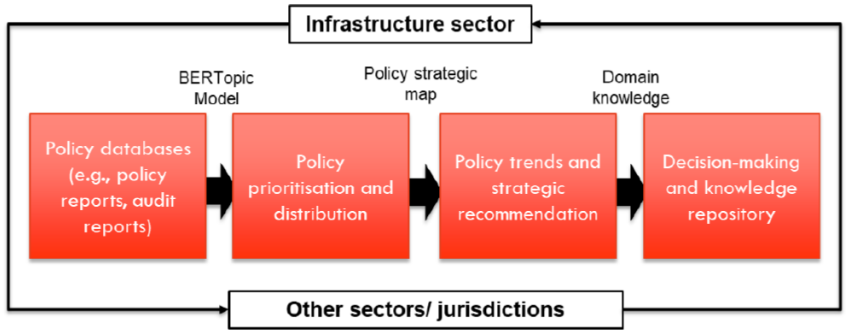
3.2 Policy prioritisation - topic spectrum
Classifying extracted policies based on their level of specificity to provide a granular view of major discussions in documents.

3.3 Policy identification
Leveraging Large Language Models (LLMs) to assign descriptive names.

3.4 Policy trend analysis
Developing a contemporary relevance analysis to reveal the dynamic nature of policies over time.

3.5 Policy recommendation - Infrastructure policy strategic map
Developing infrastructure policy strategic map to explore the characteristics of infrastructure policies.





Hong, W. T., Whyte, J., & Xue, J. (2024). A natural language processing (NLP)-driven framework for policymaking in infrastructure development. Accepted by Journal of Construction Engineering and Management (A*)*