cdbb
Centre for Digital Built Britain

Sector perspectives on digital built Britain capabilities

Kirsten Lamb and Charles Boulton

July 2019
Series No. CDBB_REP_024
DOI:

UNIVERSITY OF CAMBRIDGE

Centre for Digital Built Britain

This paper is published in the CDBB publication series.

Acknowledgements:
This research was funded by the Centre for Digital Built Britain (CDBB). www.cdbb.cam.ac.uk

Sector perspectives on digital built Britain capabilities

Kirsten Lamb and Charles Boulton

While every sector retains its own characteristic behaviours, processes, dynamics and issues, the inevitability of convergence and integration make it more critical than ever to understand and manage how digitalization and the built environment play a supporting and enabling role to decision making. The transition to digital built Britain will, to differing extents, play out across each sector – both individually and where sectors, users, service providers and asset owners and managers converge. We – the researchers, organisations, policymakers and citizens of the UK – will need, in the coming years, to define and acquire the capabilities needed within, between and across the sectors that deliver essentials such as housing, transport, power, communications, health, education and justice.

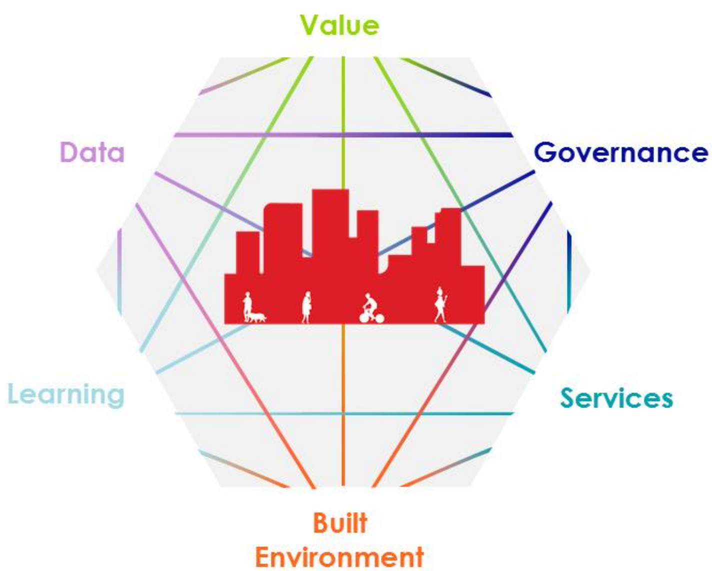

Figure 1: There is considerable interplay between each of the capabilities – which differs for each sector.

CDBB's Capability Framework outlines many capabilities that will be needed to develop a digital built Britain, and categorises them into:

- Stakeholder value
- Services
- Built environment
- Data, information and Models
- Governance
- Learning and adaptation
- and all of them sit within a context of drivers and trends.

Of course, as demonstrated in Figure 1, all of these categories of capability are interlinked and so should be considered as part of a system. However, considering them individual prompts certain types of question and is therefore a useful exercise. These capabilities will play out differently across the various sectors in the UK, with different pinch points and good practice in each one.

This report is a thought experiment, highlighting some of the sector perspectives on the Capability Framework (see the Capability Framework and Research Agenda summary and report documents for details), and discussing how the lessons the architecture, engineering, construction and operations (AECO), energy, housing and transportation sectors might learn from each other about adopting models of assets for better decision-making.

Learning from other sectors

In each sector there are distinct features to the decision-making domain, including unique trade-offs that need to be made, and unintended consequences to monitor. For example, it is easy for politicians to say, 'We need to update existing infrastructure and we need to build new infrastructure', but given budget limitations, where are the priorities? In making roads more bicycle friendly, does that make bus routes less efficient? These are trade-offs within the sector, but there are also trade-offs outside the sector. For example, funding transport infrastructure may divert funds for other important projects such as public health initiatives. Weighing up known trade-offs before making decisions is important, but it is also important to try and monitor unintended consequences after interventions. How will new high-speed rail lines impact rural communities and wildlife corridors, for example?

In each of the sectors that intersect with the built environment, further research is needed to unite existing maps of sector decision processes, service models and built asset management frameworks to the development of digital built Britain; identify barriers to change; and develop modelling capabilities specific to the role of the sector in the wider landscape. Digital transformation is a transitional process that is occurring unevenly within and between sectors, and part of bringing about digital built Britain is ensuring that the rising tide lifts all boats. This could be accomplished through better sharing of practice between organisations using frameworks and taxonomies to support integration of capabilities into practice.

Some sectors are ahead of construction in their digital transformations and, while the assets they manage may differ in nature and complexity, we can learn how to manage the transition from identifying barriers they faced and how well their solutions have worked. These challenges as faced by the aviation and offshore oil and gas sectors are described in previous CDBB reports (Lamb, 2018a; Lamb, 2018b). Similar lessons can be taken from other sectors that manufacture or manage complex and high value assets, as these sectors have had the means, motive and opportunity to digitalise these processes in advance of the construction sector (Coleman et al., 2017).

The common challenges other sectors have faced can be broken down into technical, governance and social categories. **Technical challenges** may include issues of interoperability, scaling up data and information management from single asset to networks of assets, data accuracy and timeliness, and development of automated data description and analysis tools. **Governance challenges** include negotiating security and access to information in the face of data analytics that can piece together more sensitive insights than intended. For example, if access disparate data sets give would-be terrorists information about vulnerabilities in a transportation hub, it is a sign that the balance between security and access has not been managed well. **Social challenges** might include reluctance to invest time or money in digital transformation or bridging digital skills gaps, together with the inability to translate insights from data into value for the organization and the public.

Energy sector perspective

As an enabling resource and linking infrastructure, the energy sector touches on most other aspects of digital built Britain, powering the built environment and services, as well as the digital technology that monitors them and manages their data. The sector also has extensive physical assets of their own, from power generation sites to energy distribution grids. At the centre of a digital transformation in the energy sector is the Smart Grid. The grid could be micro or macro, with energy generated by renewable or non-renewable sources, but at its core it is monitored and managed by technology such as a network of models and digital twins. Such models of grids and physical infrastructure allow monitoring of their performance and the generation of predictive insights relating to energy production and use. This facilitates decisions about building and deploying energy infrastructure, performance improvement interventions and security measures.

Smart Grids use real-time or near real-time information and data to monitor and control energy generation and demand. The promise of Smart Grid technology is performance and behavioural insights that could reduce costs, support economic growth, increase energy security and reduce carbon emissions in the UK (Smart Grid Forum, 2014). While the UK has invested in this capability, the difficulties come in modeling the complex drivers of demand and capacity, enunciating the interdependencies between energy and other sectors, and making decisions based on those models. For example, what is the causal relationship between the uptake of electric vehicles (EVs) and the availability of charging points? What are the key predictors of energy demand in commercial and service sector buildings? How will the need for centralized power generation facilities be impacted by the opposing forces of greater availability of domestic power from renewable sources and greater demand for energy? How will external factors such as climate change impact the reliability of renewable energy sources? How will changes in public transport and autonomous vehicles impact energy demand? The entire integration agenda is a subject of exploration by the National Centre for Energy Systems Integration.[1]

The Institute of Electrical and Electronics Engineers (IEEE) is one of the key contributors to the digital transformation agenda, including the development of standards and the publication of academic research. The UK government, and the Department of Energy and Climate Change (DECC) in particular, also hold a huge stake in this area. They outline capabilities needed to develop the smart grid as follows:

- 'Provide the strategic direction on the future of the electricity system and value of smart grids.'
- 'Ensure regulatory and commercial frameworks enable and support the deployment of smart technologies and new commercial practices.'
- 'Ensure that consumers understand and are convinced by the benefits of installing smart meters and shifting demand.'

[1] https://www.ncl.ac.uk/cesi/

- ‘Maximise the economic opportunities for jobs and growth through continued investment in research and development; better engagement with SMEs of the commercial opportunities that smart grids present to grow our domestic industry and actively promote UK smart grid products and expertise in overseas markets; greater engagement in the development of European product standards; and improved cooperation between industry and research communities.’ (Smart Grid Forum, 2014)

These focus on the governance perspective of digital built Britain without explicitly addressing the social and technical barriers to adoption. However, governance support in this sector is crucial, and modelling within the energy sector informs governance with better evidence and better decision-support tools. The other pieces of the puzzle are industry investment in smart energy infrastructure, and the social aspects of managing change through digital literacy (Living With Environmental Change, 2016).

One of the chief concerns for the digital transformation of the energy sector is ensuring security and resilience are maintained. The philosophy behind smart grids potentially opens up the energy sector and its dependent systems to cyber-attack.

Meanwhile, resilient energy provision must fit within the national goals of decarbonization. While it is unlikely that the entirety of the UK’s energy infrastructure would fail simultaneously for any length of time, there is, ‘“An increasing array of options for managing tight conditions”’ (Science and Technology Select Committee, 2015). These conditions include the aftermath of climate-related disasters and malicious attacks. Choosing and managing such options is enabled by modelling supported by data and information about service levels and asset conditions.

As with the security of built infrastructure, ensuring the security and resilience of the energy grid is a focus of attention of the Centre for the Protection of National Infrastructure (CPNI) and the National Infrastructure Commission (NIC). Government working groups and industry organisations also take an interest in this issue. Measures to improve resilience recommended by the Energy Research Partnership (2018) include:

- ‘Investigate resilience measures which can be used cross-sector to establish acceptable levels of resilience to meet future needs.’
- ‘Engage a diverse set of views across society and business to establish future resilience requirements for the UK Electricity system.’
- ‘Government should work with cross-sector infrastructure parties to establish holistic resilience policies for the future.’
- ‘Infrastructure regulators to make resilience a central consideration of review periods. It should also stimulate markets to ensure relevant sectors provide resilience in their products and services.’
- ‘Organisations to build their cyber security skills and capabilities, to address growing threats, and ensure secure network resilience during technology integration.’

Urban Innovation Labs discuss many of the issues facing this sector, highlighting decarbonisation, digitalisation, decentralisation and the massive forthcoming interaction with the transport sector caused by the expected increase in the numbers of electric vehicles[2].

The questions and capabilities highlighted here echo those listed throughout the main capability framework, showing that digital transformation is simultaneously a technical, governance and social challenge.

Value – How to use digital technology to plan and measure the outcomes that the interconnected sectors in the UK require from the energy sector.

Service – How to use digital technology to provide sustainable, reliable and resilient energy to meet the UK's changing needs.

Built Environment – How to use digital tools to make better decisions while planning, using and maintaining energy infrastructure.

Data – How to collect and manage data about energy infrastructure performance securely and efficiently, while sharing appropriate material with partners in other sectors.

Governance – How to develop standards and frameworks for data and information management that align with partners in other sectors.

Learning and adaptation – How to ensure that appropriate digital skills and literacies are present throughout the sector and over the long term.

Context – How to use digital tools to manage assets in the context of drivers such as migration, climate change and increasing digitalization.

Housing sector perspective

Digital decision tools and capabilities in this sector could transform the way housing is planned, delivered and managed, from the city scale to the individual dwelling. In the sections below, some of the potential developments that could be aided by digital decision tools are discussed. However, as there has been little research into the potential value these tools could create, there is as of yet little incentive to invest. These and many other issues around the housing sector are addressed more thoroughly in a research network report for CDBB (Burgess, 2018).

Digitising the planning process

The decisions facing the housing sector involve a complex web of supply and demand, where the demand for housing is shifting rapidly with migration changes and an aging population, and the supply is struggling to keep up with the need. The need is not simply for more housing, but for more affordable housing, housing of the right types, and in the right locations. However, estimates about the need vary widely and may not represent a '"robust analysis"' (Wilson & Barton, 2018).

---

[2] See Section 2.4 here: https://doi.org/10.17863/CAM.40458 and Sections 2.3-2.4 here: https://doi.org/10.17863/CAM.40459

There may therefore be the potential to model the demographics (see Capability Framework, C3) and drivers, but a key capability needed would be to identify the relevant aspects of the wider context that would help guide this thinking. Climate change, flooding, erosion, migration, crime and the economy are all potential drivers of housing demand and performance, but whether they are included in a model depends on the scale of the asset being managed. Digitalisation could have huge benefits on the planning system, and this is explored further as a specific aspect of governance (see Capability Framework, G1).

Digitising the delivery and management of housing

If it is deployed democratically, digitalisation could enable a Housing-as-a-Service model that helps connect people with homes that meet their needs. A model of availability and demand could translate information about housing into a user-friendly format for apps, enabling those with unstable situations to easily find their next home.

Integrated information systems could also help make high-density housing safer by managing crucial data and supporting through-life monitoring, as suggested by the Hackitt Review (Hackitt, 2018).

There are unique issues with capturing data about the existing building stock (see Capability Framework, B3). While it is likely worth the investment to capture detailed scans and data for a bridge or museum, the ROI on doing so for individual dwellings is unlikely to attractive. However, retrofitting homes with smart technology may be worthwhile to ensure that their energy performance and structural safety are up to current standards. Identifying the trade-offs here would require appropriate research. Additionally, standards to ensure the capture and management of data about individual homes when refurbishments, extensions, demolitions and other major works are carried out could help planners, architects and homeowners better understand the performance of residential buildings and their relationships to each other, to transport, energy, ICT, water and waste infrastructure, and to the natural environment.

The housing sector can be viewed as a microcosm of digital transformation, as solving the technological problems are relatively easy compared to the social problems; how comfortable will citizens be with sensors in the home, and the feedback and behavioural nudges that might result? Adoption is varied, with some homes embracing smart home technologies like Alexa, Siri and Google Assistant, and others seeing devices that listen to and record them as a violation of privacy, an unnecessary or unobtainable luxury, or an unfamiliar technology (Mani & Chouk, 2018).

There is a strong intersection with the energy sector in this area, with smart home energy management systems (HEMS) such as Nest seeing widespread adoption in ways that are closely linked with the wider smart home trend (Sanguinetti et al., 2018). This demonstrates the need and ability for sectors like energy and housing to work together on addressing problems such as energy use. At the same time as monitoring becomes smarter, however, the proliferation of devices in homes will continue to drive demand for energy up, leading some environmentally conscious households to invest in creating their own solar, wind or geothermal energy, fragmenting the energy grid and changing the supply and demand relationships. The service model for energy in the UK needs to consider these factors and how they will affect energy production and consumption within digital built Britain.

Digitalisation may take place within new build homes themselves and could generate insights that help the lives of their occupants. However, while smart homes are certainly possible, research has not yet established whether, for example, the growing population of older adults would benefit from and embrace digital technology in the home. Indeed, there are barriers to digital adoption at various intersections of age, gender, physical ability, education level and so forth (e.g. Mani & Chouk, 2018; Sanguinetti, Karlin, & Ford, 2018). Any actions taken toward digitalization of the housing sector may have unintended consequences, such as social isolation, exclusion or environmental impacts that should be researched, modeled and managed accordingly.

Value – How to use digital technology to plan and measure the outcomes that add value to the lives of citizens in the UK.

Built Environment – How to use digital tools to make better decisions while planning, building and maintaining housing in the UK.

Data – How to collect and manage secure, anonymous and interoperable data about residents that enable planners to make better decisions.

Governance – How to develop standards and frameworks for data and information management that benefit the lives of citizens in the UK.

Learning and adaptation – How to ensure that appropriate digital skills and literacies are present throughout the planning sector and over the long term.

Context – How to use digital tools to manage housing in the context of drivers such as changing demographics, flooding and economic shifts.

Transportation sector perspective

Transportation networks are the routes by which we visit our families and friends, get to work, receive shipments of food and other goods, and engage in leisure activities. They allow us to live our lives but make us heavily reliant on built infrastructure. As with any aspect of the built environment, digital capabilities can enhance the building and management of physical infrastructure for transportation. Capabilities needed in the transportation sector for digital built Britain are covered in depth by Urban Innovation Labs in reports for CDBB[3]. They include physical infrastructure management, managing changes in demand and consequences arising from those changes, decarbonisation and better integration of the sector with infrastructure providers. Several of these are discussed in brief below, but for further details please see the Urban Innovation Labs reports.

As with other critical national infrastructure, transportation faces various difficulties arising from aging and inefficient assets. Other issues arise as administration rights change during devolution and as changes are proposed to management regimes[4]. Other problems in asset management may arise as new transportation technology emerges. For example, clear road markings are essential for the safe

[3] See Section 2.3 here: https://doi.org/10.17863/CAM.40458 and Sections 2.2.1-2.2.2 here: https://doi.org/10.17863/CAM.40459
[4] See Section 2.3 here: https://doi.org/10.17863/CAM.40458

operation of autonomous vehicles, so maintaining these markings on all roads nationwide may become a priority that an automated system could manage. Decision-making in the transportation sector can also be aided by digital tools. For example, planning parking or charging points for a city, modelling demand scenarios could explore the cost effectiveness of alternative options to meet predicted demands.

The next fifty years are likely to see large-scale changes to demand and supply in the transportation sector. The proliferation of autonomous and electric vehicles will have knock-on effects to the built infrastructure required for transportation. For example, autonomous vehicles may change the design of pedestrian and junction infrastructure. Proliferation of electric vehicles will require greater access to charging stations, which in turn will influence the demands on the electrical grid. Changing vehicle ownership models, commute patterns, regulatory and subsidy frameworks (for example decarbonization laws), and public transportation service models would also impact the demands on the infrastructure.

Transport in digital built Britain will involve 'closer coupling of sector with infrastructure providers'[5], for which one model is Mobility-as-a-Service (MaaS). There are various pilots in cities around the world that deploy MaaS in different ways and for different purposes. One of the most mature is in Helsinki, where the goal is to make it unnecessary for any private citizen to own a car by 2025 by providing on-demand transportation. Their app, *Whim*, allows people to pay for and plan trips across all modes of transportation including train, taxi, bus, car-share or bike-share. This multi-modal integration relies on interoperable data from various service providers. However, trust of third-party aggregators is a major barrier to maturity. 'The trusted mobility advisors link the services of the various private and public operators, arranging bookings and facilitating payments through a single gateway. Accomplishing that kind of integration has proven to be such a hurdle that only a few services have emerged in this category.' (Goodall et al., 2017) Closer alignment of digitally enabled services with infrastructure could result in greater freedom of movement for all, better asset performance and the potential for new business models, so finding a way to overcome the trust barrier would be transformative to the transportation sector.

Value – How to use digital technology to plan and measure the outcomes for transportation that benefit the lives of citizens in the UK.

Service – How to use digital technology to provide integrated, multimodal service models for transportation.

Built Environment – How to use digital tools to make better decisions while planning, building and maintaining transportation infrastructure.

Data – How to collect and manage secure, interoperable data about transportation infrastructure performance, while sharing appropriate material with partners in other sectors.

Governance – How to develop standards and frameworks for data and information management that align with partners in other sectors.

[5] See Section 2.3 here: https://doi.org/10.17863/CAM.40458

Learning and adaptation – How to ensure that appropriate digital skills and literacies are present throughout the sector and over the long term.

Context – How to use digital tools to manage assets in the context of drivers such as changing demographics, climate change and increasing digitalization.

Other Sectors

Every sector that delivers services through built assets has some stake in driving the direction of digital built Britain, and needs to make decisions and trade-offs accordingly. For example, Urban Innovation Labs discuss some of the themes, issues and capability needs in the Education sector, and the Healthcare sector[6]. Digitalisation will continue to drive change in most sectors, all of which will contribute their own strengths to the greater UK built environment and the lives of people in the UK. Questions remain about how to co-ordinate all of these efforts, who owns the broader, nation-wide vision and what drivers are most effective to bring it about. The fact remains, however, that each sector has its own perspective on digitalization, and, if we combine these perspectives, there are opportunities for better understanding and better decisions.

Combining perspectives for greater insight

No sector operates in isolation. Hospitals are accessed by roads and public transportation systems, homes are powered by electricity, which in turn relies on built infrastructure for delivery. Similarly, decisions in one sector have ripple effects in others. Imagine that you have installed geothermal heat pump system in your building – which uses the ground as a heat source in the winter and a heat sink in the summer in order to reduce energy demand – and now your neighbour wants to dig a basement. This would change the geothermal properties of the ground around your building and impact your ability to use it for heating and cooling. Scale up these interactions to the national level and across more sectors and you will begin to appreciate the complexity of decisions actions taken in the built environment. Navigating this complexity will require ever-improving models that balance precision with the inclusion of data from relevant sources and stakeholders (see Capability Framework, G4).

Widening the scope of stakeholders and domains to work across sectors opens the potential to capture and process more data, which may result in more robust insights. The capability to share interoperable data between models within and between sectors would be powerful and transformational. This is at the heart of the propositions around the national digital twin and the Digital Twin Hub[7]. This capability demands an intersecting focus on data, governance and value, embodied in the work of the Digital Framework Task Force[8].

Digital tools can help decision-makers navigate complexity and gain insights from big data, but there are other capabilities needed in order to define the scope of the decision-making domain and harness these insights into better actions, such as governance, literacy and capturing social value. These are described

[6] See Section 2.1 and 2.2 here: https://doi.org/10.17863/CAM.40458
[7] https://www.cdbb.cam.ac.uk/DFTG/NDTHub
[8] https://www.cdbb.cam.ac.uk/DFTG

throughout the capability framework and demonstrate that the transformation to digital built Britain can only be managed through a combination of capabilities and tools.

References

- Burgess, G. (2018). *Housing Digital Built Britain Network - Final Report* [Report]. https://doi.org/10.17863/CAM.40452
- Coleman, C., Damodaran, S., Chandramouli, M., & Deuel, E. (2017). *Industry 4.0 and predictive technologies for asset maintenance | Deloitte Insights*. Retrieved from Deloitte Insights website: https://www2.deloitte.com/insights/us/en/focus/industry-4-0/using-predictive-technologies-for-asset-maintenance.html
- Energy Research Partnership. (2018). *Future resilience of the UK electricity system: are we resilient to meet the needs of this rapidly changing world?*
- Goodall, W., Fishman, T. D., Bornstein, J., & Bonthron, B. (2017). The rise of mobility as a service. *Deloitte Review*, (20), 112–129.
- Hackitt, J. (2018). *Building a safer future: Independent review of building regulations and fire safety* (Final Report No. Cm 9607). Retrieved from Ministry of Housing, Communities & Local Government website: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/707785/Building_a_Safer_Future_-_web.pdf
- Lamb, K. (2018a). *Challenges of Digitalisation in the Aerospace and Aviation Sectors* [Report]. https://doi.org/10.17863/CAM.26276
- Lamb, K. (2018b). *Challenges of Digitalisation in the Offshore Oil and Gas Sector* [Report]. https://doi.org/10.17863/CAM.25071
- Living With Environmental Change. (2016). *How can UK energy systems be made more resilient to the impacts of climate change?* (Policy and Practice Notes No. 31). Retrieved from http://www.relu.ac.uk/landbridge/LWEC%20pp31.pdf
- Mani, Z., & Chouk, I. (2018). Consumer Resistance to Innovation in Services: Challenges and Barriers in the Internet of Things Era. *Journal of Product Innovation Management*, *35*(5), 780–807. https://doi.org/10.1111/jpim.12463
- Sanguinetti, A., Karlin, B., & Ford, R. (2018). Understanding the path to smart home adoption: Segmenting and describing consumers across the innovation-decision process. *Energy Research & Social Science*, *46*, 274–283. https://doi.org/10.1016/j.erss.2018.08.002
- Sanguinetti, A., Karlin, B., Ford, R., Salmon, K., & Dombrovski, K. (2018). What's energy management got to do with it? Exploring the role of energy management in the smart home adoption process. *Energy Efficiency*, *11*(7), 1897–1911. https://doi.org/10.1007/s12053-018-9689-6
- Science and Technology Select Committee. (2015). *The resilience of the electricity system* (HL Paper No. 121). Retrieved from House of Lords website: https://publications.parliament.uk/pa/ld201415/ldselect/ldsctech/121/121.pdf
- Smart Grid Forum. (2014). *Smart Grid vision and routemap*. Retrieved from Department of Energy and Climate Change website:

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/285417/Smart_Grid_Vision_and_RoutemapFINAL.pdf

- Wilson, W., & Barton, C. (2018). *Tackling the under-supply of housing in England* (Briefing Paper No. 07671). House of Commons Library.