Centre for Digital Built Britain

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Future Cities in the Making: overcoming barriers to information modelling in socially responsible cities

Final Reporting

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Foreword

The project "Future Cities in the Making – overcoming barriers to information modelling in socially responsible cities" was funded by the Centre for Digital Built Britain under the Innovate UK grant (No. RG96233). The project idea was initiated by two CDBB mini-projects on BIM and urban planning, delivered by Professor Phil Allmendinger and Dr Franziska Sielker in 2018. A major outcome of these mini-projects was the recognition that whilst information modelling is maturing, planning departments and smart city approaches are not yet not linked to information modelling. This current project specifically aimed to identify what it is that is preventing spatial planning departments in the UK from joining this digital journey. In this way, the project aims to help get the most out of the opportunities that digital tools present to cities, ensure that tools are designed to meet the needs of citizens, and to make sustainability a true foundation of urban design.

City Information Modelling may still be a futuristic idea. However, we strongly believe that software, policy, and governance design today can pave the way to harvesting the fruits of digitalisation in the future. By identifying barriers to information modelling, this project aims to contribute to future urban design, help develop efficient governance structures and help outline today's needs for policy to prepare the planning practices of tomorrow.

This project was delivered by Dr Franziska Sielker as the Early Career Lead Researcher, and by Amarynth Sichel, who joined the project as a Research Assistant in November 2018. Franziska therefore wants to specifically thank Amarynth Sichel for having substantially contributed to making this project a success, and wishes her a good and successful future. Franziska also thanks Prof. Phil Allmendinger for having acted as the PI to allow for eligibility. Further, we thank Elisabeth Kaufmann and Santhiya Vanajanathan from the chair of International Planning Studies at TU Dortmund for the support in some visualisations.

This project would not have been possible without the direct and indirect support of numerous people. We would like to thank all the stakeholders who generously offered their time and expertise, and spoke with us. We have had the opportunity to speak to more than 43 people over the course of the project, providing us with a good overview and bring together different perspectives in terms of stakeholder needs, local and regional contexts and planning systems and challenges. Thanks to everyone. We hope for a fruitful future collaboration as well.

We would also like to thank CDBB for their constructive cooperation throughout the project. We thank Alexandra Bolton for consistently providing links with different stakeholders in the field of digitalisation and urban planning. Andrew Smith has continuously supported the Early Career Projects with great enthusiasm. Thank you for the support and availability. We thank the Department of Land Economy for hosting us over the last 9 months. In particular, we would like to thank Laura Cave, Katerina Tsormpatzoglou and Sam Wyatt, who helped us administratively with complex contracting arrangements, numerous travel claims and so forth.

Finally, we thank the wider CDBB community, and in particular Dr Gemma Burgess, Dr Timea Nochta, Dr Li Wan and Dr Jennifer Schooling for exciting discussions and collaboration across different projects.

Planning in the UK is at a crossroads, and we hope that this project may contribute to instigating a more strategic approach to planning by using digital tools, and thereby help to shape liveable cities for future generations.

Abstract

Building and City Information Modelling (BIM and CIM) could potentially facilitate better planning outcomes, more efficient service provision, and more inclusive community engagement. In doing so, these technologies could help deliver on some of the goals common amongst aspiring smart cities, using data to improve efficiency, services and quality of life. However, information modelling uptake has been slow, and most cities do not incorporate information modelling in their planning processes. Looking beyond information modelling, planning systems worldwide have been slow to adapt to the digital future: most planning systems have not yet digitalised, and lack the tools and incentives to help local authorities and planners make use of emerging technologies. This research explores the barriers to and opportunities for using information modelling in planning in the UK, and probes the ethical questions around how cities and local authorities can use data while protecting citizens' right to privacy.

The project analyses these questions through three case studies in two UK nations, relying on stakeholder interviews, document analysis, and a questionnaire. We selected three case studies, Bristol, Cambridge and Scotland, to reflect areas with different socioeconomic profiles, planning systems, local authority sizes, and governance structures. The project identified that organisational, data-related, technological, human resource, financial and legal barriers are interrelated. Solutions for overcoming these barriers are themed around enhancing collaboration, leadership, business case and investment, innovation and strategic planning, and privacy..

Keywords – City Information Modelling; Building Information Modelling; smart cities; planning systems; data privacy and security

Executive Summary

This research probed the relationship between Building Information Modelling (BIM) and the UK planning system. BIM is a set of digital tools, processes and standards used to capture and store data associated with a construction project so it can be used collaboratively by everyone working on the project and those responsible for the assets' subsequent operation. The research sought to answer three main questions:

1. What role does information modelling play in supporting sustainable planning and development?
2. What are the barriers to implementing information modelling for planning and how can they be overcome?
3. How can national and local governments ensure socially responsible data use?

To answer these questions, we took a mixed methods approach. We selected three case studies—Bristol, Cambridge, and the devolved nation of Scotland—so we could investigate information modelling's potential in areas with different economic, demographic, governmental and planning contexts. We conducted desk-based policy and document analysis, conducted over 40 interviews with planning stakeholders from the public and private sector, and triangulated our findings with a questionnaire.

Opportunities for information modelling: the role of information modelling in supporting sustainable planning and development

Our analysis showed that information modelling can support sustainable planning and development by providing tools that can potentially deliver better planning outcomes, greater efficiency, and improved public participation. Specifically, planning stakeholders envisioned using information modelling in planning to create an integrated City Information Model (CIM) that could be used to model changes to see impacts on things like: jobs delivered; square footage created; types and numbers of homes delivered; air quality; traffic flow; energy use; planning requirements like height or density requirements; subterranean assets; and future plans (e.g. for transportation investment). Thereby, information modelling was also seen as an opportunity to overcome data silos and foster collaboration across sectors. There was hope that such a model would be able to accept BIM models from users of the planning system, to outsource the creation of the CIM, that such a model could enable better asset maintenance and operations above and under the surface, and facilitate better public engagement through the use of 3D modelling.

Barriers to information modelling in planning

Our research showed that local authorities face a number of barriers to using information modelling in planning. In general, we found that barriers fell into one of six main categories: organisational, data-related, technological, human resource, financial and legal barriers (Table 1).

Studying these barriers revealed two key insights:

1. Barriers to information modelling are, almost without exception, barriers to digitalisation in general for local authorities and the built environment. This means that to reap the benefits of any major digitalisation endeavour, local authorities and their allies will have to contend with these barriers. Conversely, it also means that overcoming these barriers has the potential to deliver value beyond the value that just information modelling can bring.

2. Barriers to digitalisation and information modelling are closely interlinked. For example, financial barriers can prevent training or hiring personnel, creating human resource barriers, which then can lead to poor data management, which creates data-related challenges. One can map out causal chains starting with a barrier in any one of the six categories. This has implications for the approach to overcoming these barriers: focusing on just one type of barrier is necessary, but

not sufficient for overcoming the barriers to information modelling in planning. A prioritised and coordinated approach will be necessary.

Table 1: Types and examples of barriers to digitalisation and information modelling for planning		
Organisational	**Technological**	**Data-related**
Fragmented government structures	Contract lock-in with technology platforms or providers	Necessary data difficult to access
Lack of leadership support	Lack of standardisation in tools and protocols	Data is not of good quality, validated or standardised
Unclear data sharing arrangements	Need for software and hardware upgrades	Level of detail in BIM is too high
Unclear information about existing data sets	Non-interoperable software systems	Insufficient data storage capacity
Human Resource	**Financial**	**Legal**
Lack of in-house expertise	Hardware and software upgrade costs	Uncertainty around what can legally be shared
Lack of technical and legal training	Cost of hiring right personnel	Time-consuming nature of getting legal approval for sharing
No time to get up to speed	Data storage costs	Insurance and liability concerns
No time for implementation processes	Training costs	GDPR and other data privacy laws and regulations

Source: own elaboration (for a comprehensive explication of all barriers see section 4.5)

Through our research, we uncovered a number of specific examples that illustrated the barriers described above. While by no means exhaustive, below are **sample barriers** from our case study research.

- Organisational challenges relating to governance models: one of our case study areas has a complex governance structure, with multiple governmental bodies involved in making and delivering on plans for the area. At present, three important bodies for determining the future of the area are governed by three different political parties. Implementing information modelling for Cambridge will likely require aligning financial resources and data flows across these disparate governmental bodies, which may prove complex and challenging.
- Financial challenges around data storage: some local authorities pay £30 per GB for their data. Depending on the size of the files involved, this cost could become prohibitive to local authorities.

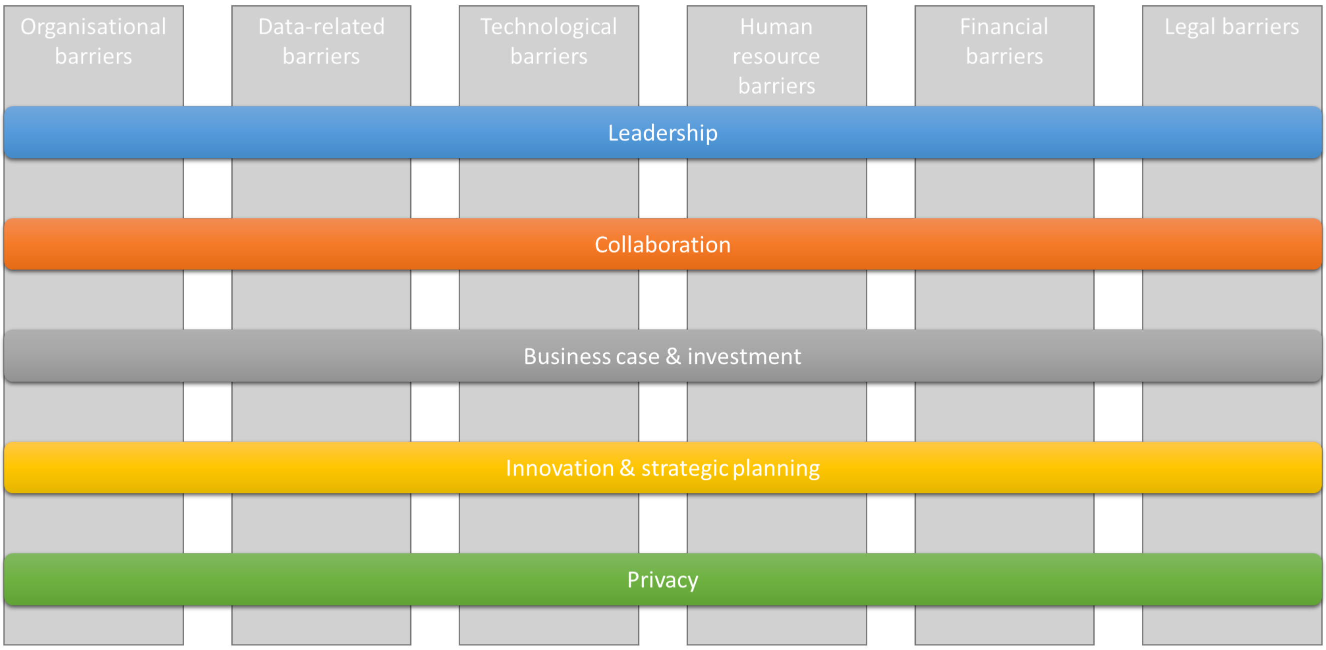
- Human resource/legal challenges around data sharing: many local authorities we spoke with had a hard time sharing data even within their organisation, either due to actual legal barriers, or just due to uncertainty regarding what is permissible. This cements data silos
- Legal challenges around sharing models: there is no liability system set up to de-risk sharing and using models made by others. This makes it difficult for larger scale collaboration, not to mention duplication of efforts.
- Legal challenges around knowing what to share: one of our interviewees in Scotland, who is trying to pave the way for better BIM adoption in his organisation, mapped out over 50 regulations, codes of practice and standards that he had to comply with to be able to use BIM. This creates a legal landscape that is too complex many local governments to navigate
- Legal challenges around data storage: many local authorities have no idea where their data is hosted, and amazon web services, which backs a lot of the hosted solutions, don't make accessing that information easy/possible

Overcoming barriers to information modelling for planning

Our analysis highlighted five areas for concentration to develop strategies for overcoming barriers to information modelling: collaboration, leadership, business case and investment, innovation and strategic planning, and privacy (Figure 1).

Figure 1

Cross-cutting solutions for overcoming barriers to information modelling



Source: own elaboration

As the figure above illustrates, the focus areas identified for overcoming barriers to information modelling in planning are cross-cutting, and can help remove obstacles across categories of barriers. For example, having a sound business case behind information modelling will help with organisational barriers, as it will provide decision-makers with the rationale for marshalling support behind digitalisation initiatives. That is turn will help to address financial and human resource barriers, as leaders can make the financial case for allotting funding to large capital investment as well as hiring and training personnel. The business case can also help to focus information modelling for planning, addressing data-related barriers by helping to define the types and appropriate level of detail for data in planning information modelling. Having a strong business case and investments can contribute to creating a robust environment for innovation, which will help overcome technological barriers. Finally, articulating a sound business case can help set the parameters for the appropriate uses of data, which will help make clear data needs to be shared, and what data is unnecessary. With this clarity, lawmakers can focus on creating systems that enable sharing only data necessary for achieving the aims of information modelling.

Socially responsible approaches to information modelling for planning

As the built environment becomes ever-more digitalised, questions around who owns data, who can access data, and who can profit from data become more and more pressing. In particular, as data collection and use becomes more sophisticated and more prevalent across the built environment, strong privacy protection measures must be in place to ensure that residents can access their homes and neighbourhoods without unduly compromising on their human right to privacy. We argue that the most dominant paradigm for data management at present comes from the Internet of Things (IoT), and is built around the assumption that users will acquiesce to the data collection and management terms of the service provider, or opt out of the service. If applied to the built environment, this paradigm risks jeopardising residents' right to the city. Therefore, developing a socially responsible framework for local governments to use when interacting with data from the built environment will be crucial for enabling a sound system to support planning information modelling, and other forms of digitalisation. Stakeholders may take inspiration from distinguishing between types of privacy.

Next steps

The research presented in this project highlights a multitude of barriers, and offered themes to focus on for solutions, but solutions must be tested and prioritised to ensure that the approach selected will be impactful and value for money. For example, before making large financial investments in hardware for local authorities, one must first understand how much storing BIM files will cost local authorities and what size files they will be storing, as storage costs may be a hidden cost in implementing information modelling for planning. Furthermore, if data costs are prohibitive, then addressing organisational barriers, for example, will be necessary but not sufficient to enable change. Because all barriers are interrelated, creating a base case to identify what combination of interventions are necessary and sufficient to overcome barriers should be a key output of further research.

Introduction

Building and City Information Modelling (BIM and CIM) have the potential to facilitate better planning by bringing together diverse data streams to create 3D representations of towns and cities that also include non-visual parameters like demographic, economic, energy use and environmental data. Such a model could become a decision-making support tool, helping model possible scenarios to enable better-informed planning decisions. In doing so, information modelling could support better planning processes and outcomes, making service provision more efficient and facilitating community engagement.

In this way, the promises of BIM and CIM in the planning context are congruent with the goals of undefined yet pervasive "smart city" concepts. However, information modelling is not a tool commonly used or discussed in planning, even in urban areas that are striving to become smart cities. BIM has a clear application in the architecture, engineering and construction (AEC) industries, and is a key part of the UK's Digital Built Britain Strategy, which aims to create a digitally enabled information landscape that will allow the optimisation of the built environment (CSIC and IfM Education and Consulting Services University of Cambridge, 2017, p. 1). However, BIM's relationship with planning, a discipline that plays a key role in shaping the built environment, is still undefined. This is an area worth further exploration: planning can benefit from the rich information and collaboration enabled through information modelling, and integrating BIM into the planning system can help catalyse BIM's rollout across the built environment, helping to deliver on the UK's Digital Built Britain Strategy. Furthermore, incorporating information modelling in planning can be a positive first step towards creating a national digital twin to unlock the power of data for public good.

Against this background, this project probes the relationship between information modelling and planning in the UK, exploring: (1) the opportunities for information modelling to facilitate more efficient planning and better planning outcomes; (2) the barriers that can prevent information modelling from becoming useful to planning, and (3) the relationship between data use in planning and the right to privacy, exploring socially responsible ways to use data in a digitalising built environment.

1.1. BIM, CIM and planning in the UK

BIM is defined as a set of digital tools, processes and standards for information management used to capture and store the data associated with a construction project so it can be shared by everyone working on building project and those responsible for the assets' subsequent operation (Centre for Digital Built Britain, 2018, p. 17). In 2016, the UK government instituted its BIM mandate, requiring fully collaborative 3D BIM on centrally procured government construction projects. This provided an impetus towards adoption for the architecture, engineering and construction (AEC) industries, and since 2016, BIM has been gaining traction in these areas. To further support the optimisation of the built environment through digital information use, the UK's Department for Business, Energy & Industrial Strategy founded the Centre for Digital Built Britain, and made it the custodian of the UK BIM Programme. This research intersects with the BIM agenda in the UK by bringing BIM into the planning context.

The role that BIM can play in facilitating strategic planning is not well understood, by either industry or academia. As is covered in more depth in the literature review below, the planning community has engaged more with the concept of CIM than BIM. CIM can be understood as an "approach to the generation of spatial data models in which the integration, application and visualisation of city data is used to manage and mediate the demand for land, property and environmental resources" (Thompson et al., 2016, p. 80). BIM has the potential to act as the building blocks of CIM, and once the correct level of detail is established for BIM for planning, BIM will have a key role to play in informing CIM.

1.2. Opportunities for information modelling to support planning

In the planning context, BIM and CIM can build on the advantages of 3D visualisations by combining regional and geographic information, commonly in geographic information systems (GIS) used by planners, with asset information. This information-rich model can be used in functions ranging from place-making visualisations, to public engagement, to scenario building. It represents a powerful public policy tool, as the use of information modelling could create a hub, bringing together disparate parts of government to share data and collaborate on building a vision for the future.

1.3. Overcoming barriers to information modelling

In spite of what information modelling may be able to deliver, previous research shows (Allmendinger and Sielker, 2018) and our research confirms that planning authorities in the UK are not engaged with information modelling. One of the main reasons that planning has yet to engage with information modelling is that BIM is still perceived as a tool for the AEC industries, and software that integrates GIS, which planners rely upon, with BIM is still evolving. However, information modelling is a process, not just a software package. Even if the software existed for planners, our research into barriers shows that local authorities in the UK would face serious challenges to adopting information modelling at present. Specifically, our research uncovered six general types of barriers that impede the implementation of information modelling for planning:

1. Organisational barriers
2. Data-related barriers
3. Technological barriers
4. Human resource barriers
5. Financial barriers
6. Legal barriers

Our research also highlights the deeply intertwined nature of the barriers: organisational barriers often drive financial barriers, financial barriers contribute to human research barriers, and human resource barriers create technological barriers and so on. Overcoming these barriers will require a multipronged approach, and collaboration between multiple levels of government as well as the private sector. Analysis pointed towards some preliminary areas to explore to overcome barriers to information modelling in planning. In general, these areas fell under one of five main themes:

1. Collaboration
2. Leadership
3. Business case and investment
4. Innovation and strategic planning
5. Privacy

1.4. Data ethics and privacy

As the UK pushes towards collecting and using data in the built environment, it is imperative that both national and local governments keep questions around data ethics and privacy in view. Our analysis firmly establishes the right to data privacy, and explores the pitfalls of applying the logic of the Internet of Things (IoT) to the built environment. This project approaches the smart city question from the perspective that citizens must be free to interact with public spaces without jeopardising their right to privacy. The government's approach to the right to privacy has ramifications beyond the planning system: in the 21st century, responsible data stewardship will come to help define responsible, legitimate democracy.

1.5. Impact of research

While this research was focused specifically on the barriers to a specific data-enabled process, we discovered that the barriers we uncovered to information modelling were often barriers to digitalisation in general. In this context, digitalisation is understood as the use of digital technologies to fundamentally change work processes, as opposed to digitisation, which is understood as making a formerly analogue work process digital. Of the barriers we found, very few were specific to information modelling; the vast majority hinder any efforts towards digitalisation in general. Therefore, the impacts of our research on barriers is two-fold. First, the paper identifies focus areas, where solutions are needed to create an enabling environment for information modelling in planning. Second, however, we have identified bottlenecks that will hinder almost any effort towards shifting work processes to take advantage of the public benefits that data use can deliver. Focusing on addressing these trouble areas will help facilitate digitalisation for planning in general, not just information modelling. Finally, this research seeks to contribute to the debate around how government should approach data ethics and privacy for the built environment.

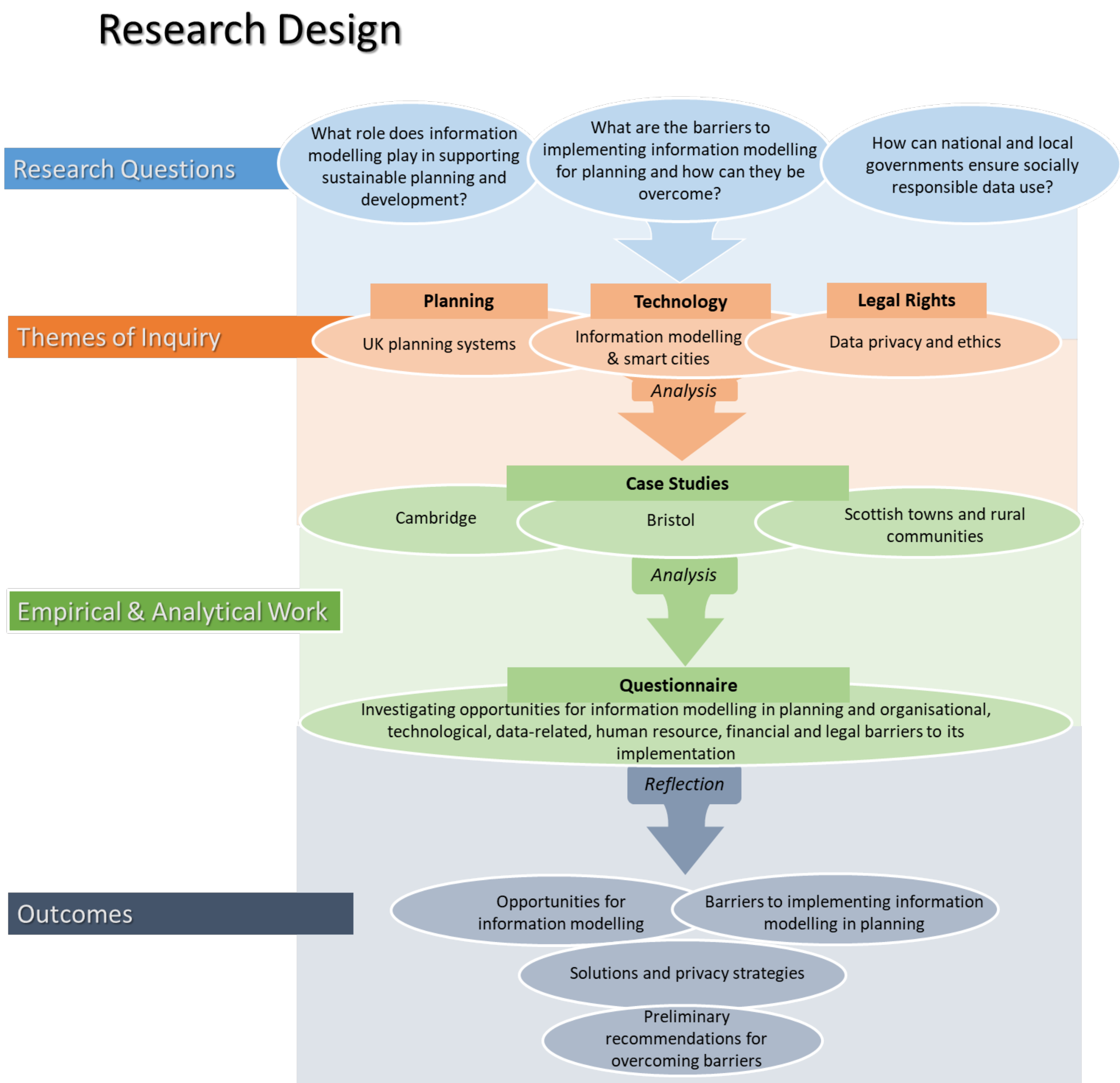
1.6. Potential impact for a Digital Built Britain

This research has six main potential impacts for a Digital Built Britain. Using information modelling in planning helps unlock the value of data from the built environment, one of the aims of a Digital Built Britain. If information modelling becomes an integrated part of the planning system, this will help catalyse the roll-out of BIM, not only for government procured projects but also in the private sector. In this way, incorporating information modelling into planning benefits the planning system, helps the roll-out of BIM across the built environment, and ultimately delivers public good. Unlocking information modelling for planning can support the creation of a national digital twin, because it will catalyse information modelling across the built environment. Additionally, the types of data that would be beneficial for a national digital twin may be similar to those required for the planning system. The planning system could help gather and organise information for the national digital twin. Conversely, planning represents an area that would benefit from access to a national digital twin to better understand resource capacity. The planning system could help deliver value from built environment data to residents. Lastly, as argued above, if the barriers identified by this research are overcome, this does more than just enable information modelling in planning. Addressing these barriers will pave the way for successful digitalisation initiatives across planning systems, which could in turn influence the ways in which other local authority departments operate. Overcoming barriers to information modelling in planning has the potential to open doors across local government, triggering a digital transformation to deliver data-driven benefit to the public.

1.7. Research design and report structure

This analysis was designed to uncover ways that BIM can support the planning system, identify the bottlenecks that prevent information modelling from being implemented in planning, and lay the groundwork for developing solutions to overcome these barriers. The research was designed to answer three main questions (1) what role can information modelling play in supporting sustainable city development; (2) what are the barriers to implementing information modelling for planning and how can they be overcome; and (3) how can national and local governments ensure socially responsible data use. These questions informed our themes of inquiry around the planning system in the UK, information modelling and smart cities, and data privacy laws. To further explore these questions, we conducted three case studies, representing areas of different sizes, with different socioeconomic indicators, planning systems, and governance structures. Analysing the case studies revealed six major types of barriers, which structured the focus of the rest of our analysis (Figure 2).

Figure 2

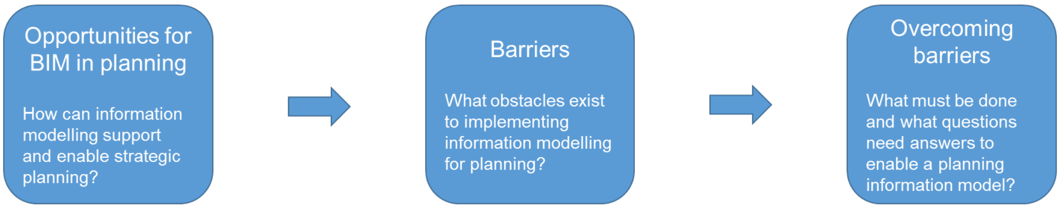


Source: own elaboration

The structure of this report broadly mirrors our research design. Following this introduction, the Literature Review in section 2 below situates our study, exploring prior research in this area to illustrate gaps in knowledge. As the literature review below illustrates, there is no robust body of work focused on the relationship between information modelling and planning. Therefore, the literature review analyses what has been written, and draws on literature from related smart city discussions. Section 3, the Methodological approach and structure of work, provides the methodology that guided the research. Section 4, the Analysis and discussion, presents the bulk of the analytical work, providing our findings. This section first explains our case studies, and then the opportunities for information modelling to disrupt planning. Next, it analyses the organisational, data-related, technological, human resource, financial and legal barriers to information modelling. It then lays the groundwork for further work to create an agenda for overcoming barriers to information modelling in planning (Figure 3).

Figure 3

Structure of Analysis



Source: own elaboration

Finally, the analysis revisits the right to privacy in a digitalising world. The last written section of the report, section 0, presents conclusions and recommendations for next steps. Following references are annexes with supplementary information from the project.

2. Literature Review

2.1. Background on UK planning systems

As our research is investigating digital transformations in planning, we have considered the defining elements of the UK planning system. The system is plan-led, in that national and local planning policy is set out in formal development plans indicating what developments should and should not gain permission. The system is also devolved, with each of the four UK countries operating under its own planning system, and with local and neighbourhood planning offering further levels of devolution in England.

Part regulatory process, part strategic assessment, part governing framework, and part futures project, planning in the UK has a number of definitions (for a discussion of evolution and use of the spatial planning concept in the UK, see Allmendinger, 2016). However, for the purposes of this report, planning can be understood as a system for aligning visions and resource to support and enable the future of communities and regions.

This research focuses on geographies under the English and Scottish planning systems, so the background below relates specifically to these two systems; however, we believe that the findings of this report are generalizable to other planning systems in the UK.

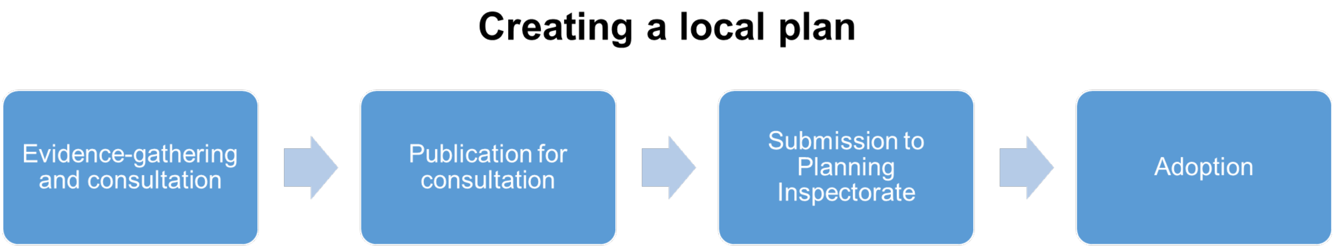
2.1.1. Creating local plans and planning applications

The processes for creating local plans as they are called in England, or local development plans as they are called in Scotland, are similar enough that generally speaking, they follow the same routes.

Creating local plans

Local plans are the main local policy documents through which planning authorities set out the overarching strategy for their areas, setting a vision for future development and identifying key locations for growth. Plans set out where new development should and should not occur, including housing, education, economic, transport and other infrastructural development. In England, plans are made by unitary authorities, non-metropolitan districts, metropolitan districts, or London boroughs. In Scotland, plans are made by councils and national park authorities (for reference, see Figure 7 and Figure 9 below). As is outlined in Figure 4 below, first the local planning authority gathers evidence and engages in consultations, then the plan is reviewed, and eventually after necessary alterations, adopted. Because planning touches on so many different sectors, such as education, health and environment, it is necessary for planners to get accurate information regarding the needs, plans and constraints of different departments. This issue wound up becoming significant in the analysis below.

Figure 4

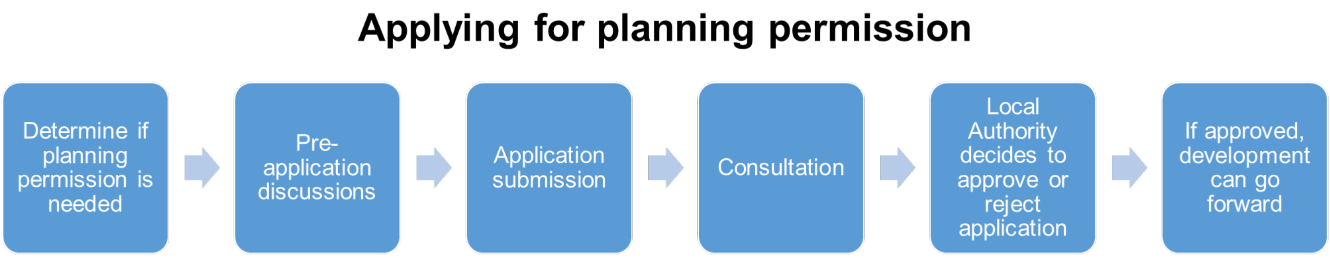


Source: own elaboration

Planning application process

When development requires approval, it goes through a process, which is similar in England and Scotland. First, an applicant will determine if planning permission is required. If it is, the applicant will often choose to enter into pre-application discussions with the relevant decision-making authority. Next, an application is submitted, and after consultation and a deliberative process, the application can be approved or rejected. If it is approved, development can proceed (Figure 5).

Figure 5



Source: own elaboration

2.1.2. Planning jurisdiction, legislation, regulation and administrative structure in England and Scotland

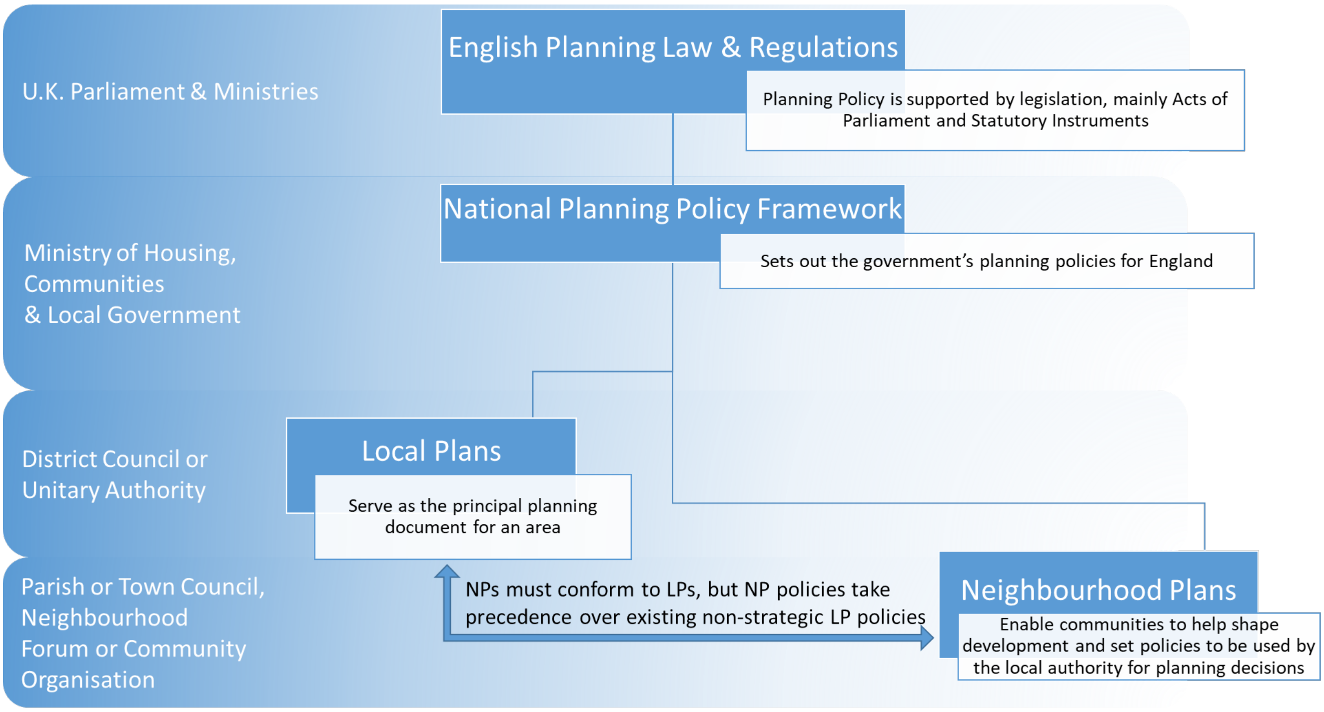
While in broad brush strokes the English and Scottish planning systems are alike, there are a few notable differences. Most relevant for the purposes of this analysis, they are overseen by different national bodies, governed by different legislation, and have different administrative structures. The two systems also differ by the strategic scope of plans. Scotland has four areas that make Strategic Development Plans, which sit at a geographic level above local development plans. These are statutory plans that cover four large city-regions, namely, Aberdeen, Dundee, Edinburgh and Glasgow. Scotland does not have any community statutory planning. England, on the other hand, does not have statutory regional planning, but can have neighbourhood plans that have statutory status.

English planning jurisdiction, legislation, and administrative structure

In England, the UK Government is responsible for planning legislation. It sets out planning policy, mainly in the form of Acts of Parliament and statutory instruments. The Ministry of Housing, Communities and Local Government is responsible for creating the National Planning Policy Framework, which sets out the Government's planning policies for England. There are over 300 councils in England, responsible for making local plans for their areas. District councils or unitary authorities make local plans, in accordance with the process outlined above, that serve as the principal planning document for their areas. Bodies responsible for smaller geographic areas can make neighbourhood plans, which then become a statutory consideration. Neighbourhood plans must conform to local plans; however, neighbourhood plan policies do take precedence over existing non-strategic local plan policies (Figure

6). The bulk of this analysis is centred on planning at the local plan level, so the relationship between local and neighbourhood plans does not feature in this analysis.

Figure 6: Planning jurisdiction, legislation and regulation in England

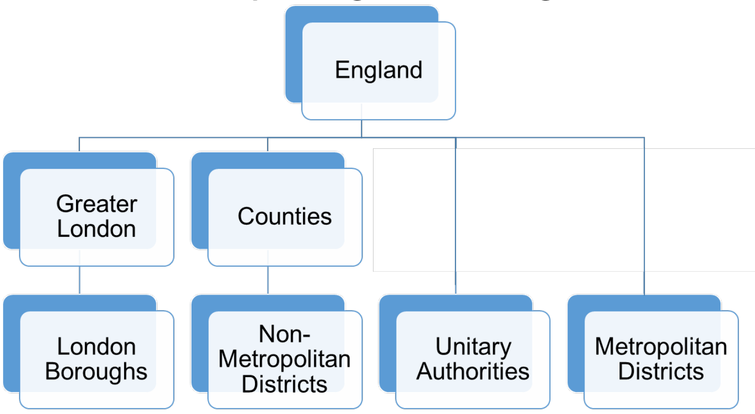


Source: own elaboration

The administrative organisation of relevant bodies related to planning in England forms a hierarchy. Geographically, at the apex rests England; however, jurisdictionally England has no separate national government and so the UK Government sets policy for England, as explained above. Below England, both in terms of geographic area covered and jurisdiction, sits the Greater London Authority and county councils. County councils cover a county-wide area and provide the majority of public services to that area. In general, unless other arrangements are made, county councils are responsible for education, highways, transport planning, passenger transport, social care, libraries, waste disposal and strategic planning. Below county councils are district councils. District councils, sometimes called city councils if the district has city status, are responsible for housing, leisure and recreation, environmental health, waste collection, planning applications and local taxation collections. However, not every area is incorporated under county council jurisdiction. Unitary authorities and metropolitan boroughs exist as one tier of government, combining the functionalities of county and district councils described above (Figure 7).

Figure 7

Relevant planning bodies in England



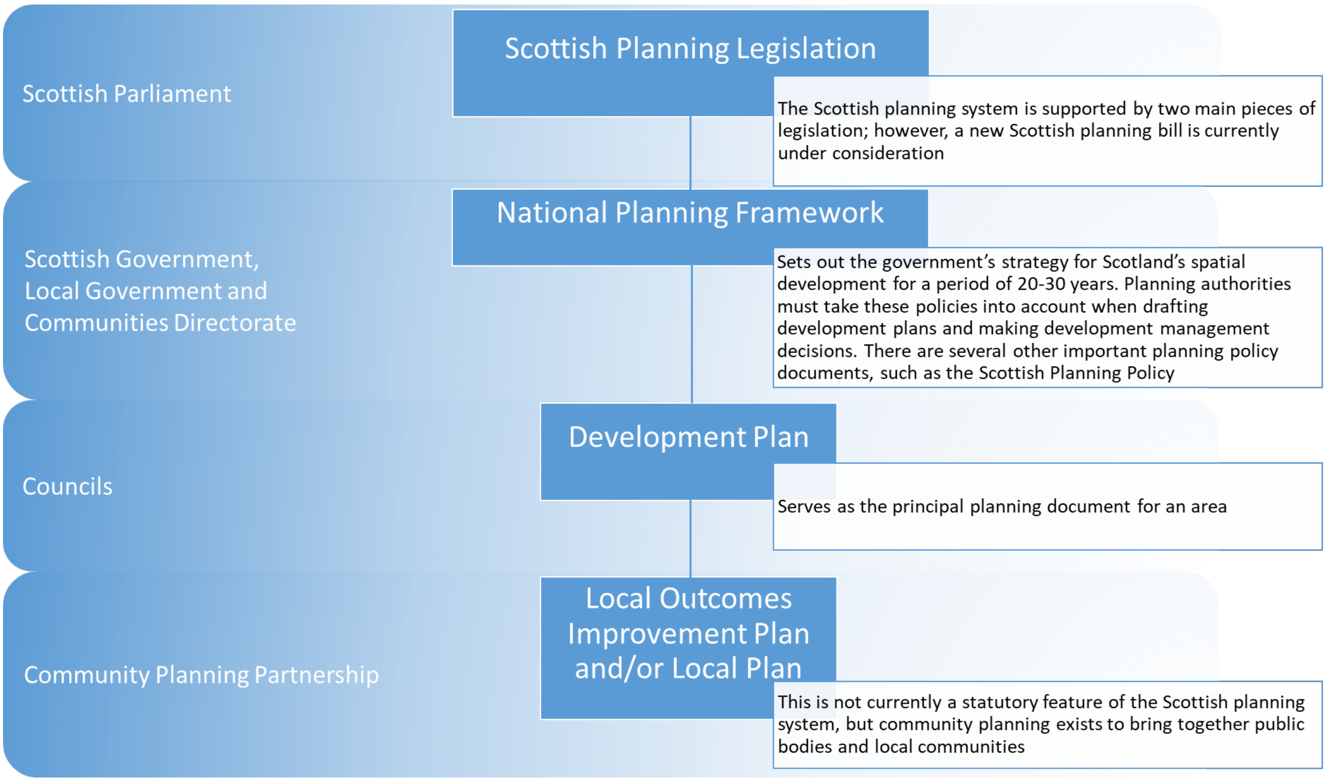
Source: own elaboration, based on Office of National Statistics, n.d.

Scottish planning jurisdiction, legislation, and administrative structure

Planning in Scotland is under the jurisdiction of the Scottish Government, which produces planning legislation. Notably, there is a major planning bill under consideration presently, which may make significant changes to planning in Scotland. The Local Government and Communities Directorate in the Scottish Government produces the National Planning Framework, which is moving towards its fourth iteration (due for publication in 2020). This document lays out Scotland's strategy for spatial development, and along with several other policy documents forms the Scottish Government's key planning policies. In Scotland, there are 32 local councils and they are responsible for making local development plans for their areas. These local plans set the strategic vision for development in each local council area (Figure 8). There is an option in the Scottish planning system to incorporate community planning through Community Planning Partnerships, but plans made this way do not have statutory standing and are not of material consideration for this analysis.

The relevant bodies related to planning administration in Scotland form a slightly more simple hierarchy, as compared to England. At the top of the system sits the Scottish Government, both jurisdictionally and geographically. As was mentioned above, Scotland has four city-region areas that make Strategic Development Plans the city regions of Aberdeen, Dundee, Edinburgh and Glasgow. These plans are made by groups of local councils. While not all areas are covered by strategic development plans, all of Scotland is covered by a local development plan, made by councils and national park authorities to guide development in their areas (Figure 9).

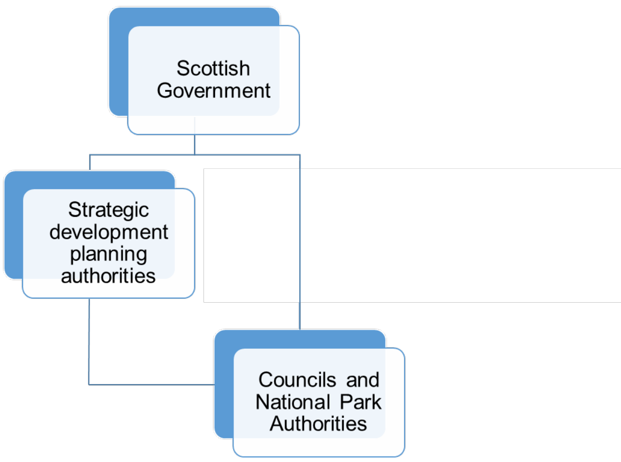
Figure 8



Source: own elaboration

Figure 9

Relevant planning bodies in Scotland



Source: own elaboration

This summary of the relevant processes, planning documents, and administrative bodies will be helpful in framing the discussion below on barriers to and opportunities for information modelling in planning.

2.1.3. Building Control and Building Standards

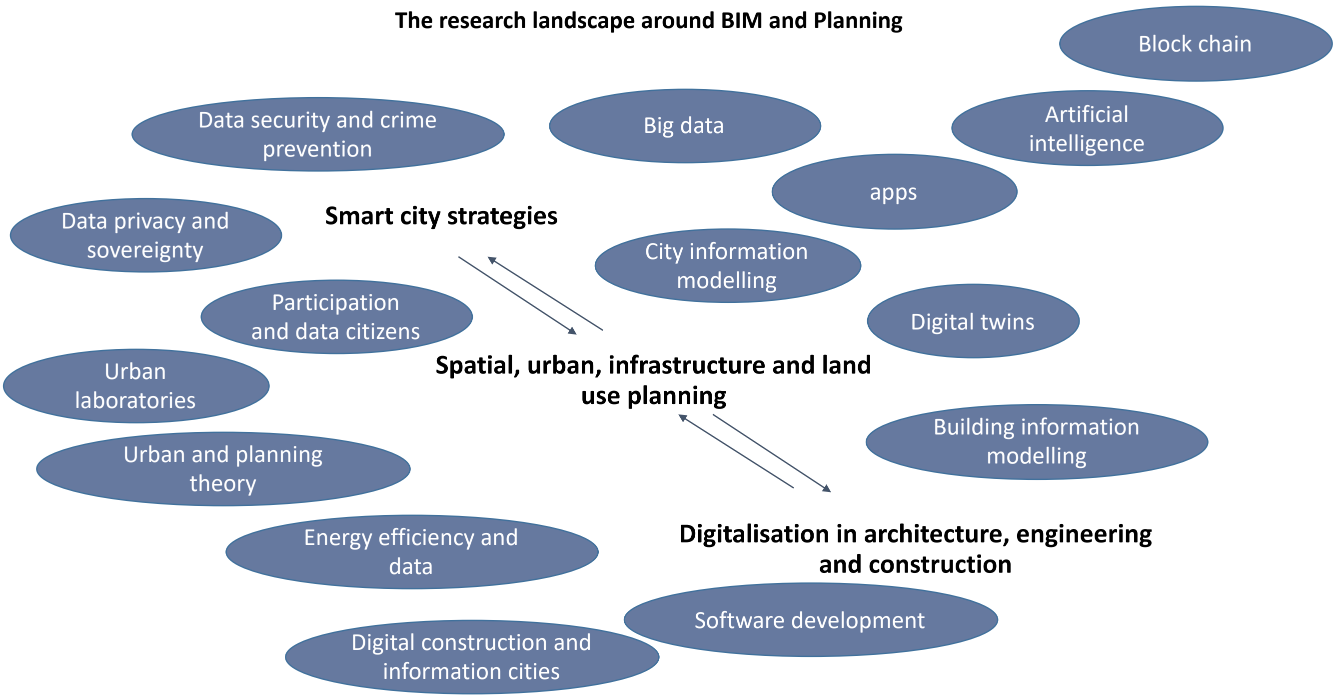
While not formally part of the planning process, our research highlighted how Building Control, as it is called in England, and Building Standards as it is called in Scotland has a role to play both in digitalising planning and in supporting the implementation of information modelling for planning. Building Control or Standards represent the minimum standards for design, construction and alterations to virtually every building. While getting building regulations approval is different from planning permission, some of the data that is collected through the building regulations process, like for example, information on building starts and completions, is useful to plan-making as it can help planners better understand what was actually built. In England, local authority building control departments accept applications, as do Approved Inspectors for building regulations approval. In Scotland the building standards system is essentially administered and enforced by local authorities.

2.2. The research landscape around information modelling and planning

Due to the nature of the research design, the project necessarily crosses a variety of disciplines from the humanities and social sciences. Research on information modelling and planning is represented through a number of research themes a that are interlink with architecture, engineering and construction (AEC), spatial planning, urban studies, and law. The three overarching topics in research are (1) smart city development, (2) spatial urban, infrastructure and land-use planning and (2) digitalisation in AEC.

Scoping the broad set of literature, we identified 14 themes that form the research landscape (Figure 10). In the following, we give a brief summary of the most important elements of this emerging research landscape.

Figure 10



Source: own elaboration

2.2.1. Urban theory and digitalisation, technologicalisation and computing

In the 21st century, the nature of what defines, makes or constitutes the urban has been the subject of increasing theorisation, leading to what now constitutes ‘urban theory’. This line of research essentially asks: what are cities about? Theoretical approaches to the city aimed to link city development with global developments; however, others argued that not every city is the same. Therefore, theories about the urban take interest in the question of what is individual to each city, or in other words, what is different about each city’s specific urban ‘membrane’ and what makes them distinct. In their paper “The nature of cities: the scope and limits of urban theory” Scott and Storper (2015) provide a concise overview of the main strands of development in urban theory. Urban theory considers the dynamics of social life, which are inherently urban, and those that appear outside of urban landscapes. It theorises commonalities across different types of cities, organisational processes and the governance of urban nexuses (Scott and Storper, 2015; Storper and Scott, 2016). One challenge urban theorists take up is the question of what is inextricably urban. Rabari and Storper (2015), for example, argued that cities are increasingly coated with a digital skin consisting of sensors constantly generating new data that may increase a new form unevenness.

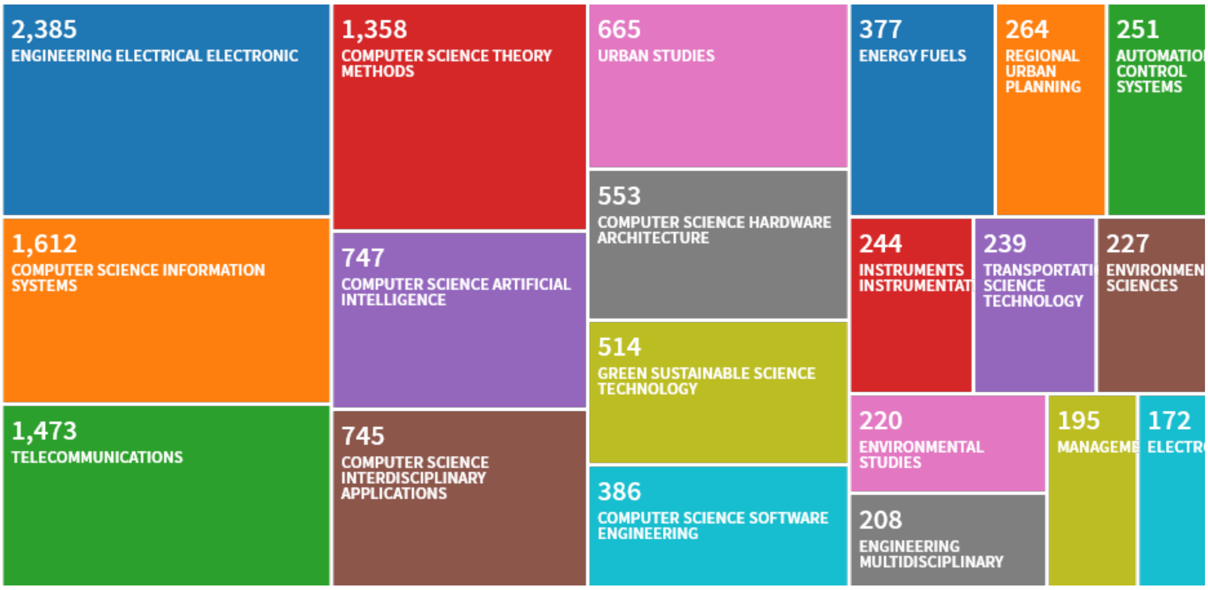
At present, the smart city debate is focused on urban areas; however, a true digital transformation necessarily involves different types of settlements, including rural areas. This is a gap in the current literature, which must be filled, as rural communities will have different needs, compared to more populous urban areas. The impacts of the production of data and its use on the social fabric are not yet clear, particularly in relation to the different needs of urban and rural areas.

To date, more people live in cities than do not. Growing cites, changing urban landscapes, economies and changes in mode of transport or trends in housing all contribute to vividly changing cities. At the same time, urban development changes constantly with the development of new technologies on the rise, and with the pace of change expected to accelerate. These shifts are most commonly covered under debates around smart cities and smart city strategies.

2.2.2. Cities and new technologies: smart city developments

Research on smart city development is proliferating, and researchers increasingly conceptualise urban developments under the influence of new technology, with theoretical developments still in their nascence. Still, the scholarly debate around smart cities matured considerably in the last decade. This is illustrated by the more than 12,000 articles listed by web of science with the key word “smart city” between 2009 and 2019 (Figure 11). It is not surprising that the main disciplines concerned with smart cities are from engineering, telecommunication and computer science, as well as increasingly from urban studies, regional planning, environmental studies or related fields.

Figure 11: Web of Science publications on smart cities by discipline, 2009 -February 2019



Source: own elaboration based on web of science

The sheer amount of literature on the smart city, with its growing diversity of arguments and detail, is too broad to summarise in this context, and any summary therefore can only represent a small number of the arguments made and the state of the art is constantly pushed forward. In relation to urban studies and regional and urban planning however, some reoccurring themes emerge.

Conceptualisations of what a smart city is: In particular, initial research aimed to identify, define and debate what a smart city is, with numerous definitions of smart cities developing. Urban and regional planners and regional scientist tend to develop broader definitions towards smart cities such as the one employed by Wilhlem & Ruhland (2018, p. 1) drawing on some of the core literature:

"smart cities are a multi-dimensional "mix of human (e.g., skilled labor), infrastructural (e.g., high-tech […] facilities), social (e.g., […] open network linkages) and entrepreneurial capital (e.g., creative […] business activities)" (Kourtit and Nijkamp, 2012), that are "merged, coordinated and integrated ["into the fabrics of the city" (Kitchin, 2014a)] using new technologies" (Batty et al., 2012), to "address social, economic and environmental problems" (Townsend, 2013), […]. In this context, smart cities can be anything, moving beyond the initial understanding of smart cities as digitalised cities focusing on a techno-cratic understanding of smart cities. In these approaches the nature of a smart or intelligence resides in the combination of digital telecommunication, networks sensors, tags and the use of knowledge management software (Mitchell, 2000). This line of research looks at a smartification and the intelligence of cities through new technologies, and is closely related to a data driven understanding of the urban fabric (Komninos, 2015). These more techno-centric definitions tend to be criticized by social and political scientists.

This opposition in understanding and this critique makes for an important part of the debate around what smart cities are about. Human Geography and political scientists have often fundamentally criticised tech-driven development of cities (see below, and for example Green, 2019, McFarlane and Söderström, 2017).

Transformation to smart cities and governance of smart cities: A huge amount of literature on smart cities discussed the practicalities and opportunities for smart city development with a focus on the opportunities offered by ICT and the governance of smart cities, including a new role for citizens. For the purposes of this research, the governance literature is of interest. Wilhelm and Ruhlandt (2018), and Meijer and Rodríguez-Bolívar (2016) provided concise literature reviews. Meijer and Rodríguez-Bolívar highlight the need for "institutional change and acknowledge the political nature of appealing visions of socio-technical governance." In the realm of smart city governance themes of debate are smarter and better decision-making (processes) through the use of new technologies, transformation of the running of administrations, new urban collaborations, including new actors in a pro-active and open-minded governance structure. Transforming to smart governed cities ultimately aims to "maximize the socio-economic and ecological performance of cities, and to cope with negative externalities and historically grown path dependencies" (Kourtit et al., 2012). The CDBB project of Timea Nochta falls in this line of research identifying ways of smartening city management.

Critiques of smart cities: The smart enough city and the right to the smart city

A main area of critique around smart city developments focuses on socially just use of digital technology, and justice-driven instead of technology-driven city development. This argument focuses on aspects of privacy and the role of citizens (for further elaboration, see below). Increasing digitalisation of cities come alongside security concerns for new forms of crime and cyber-attacks (Kitchin, 2015; Scassa, 2015).

A seminal piece, bringing together major smart city critiques was recently published by Ben Green (2019). He debates the implications for a liveable, democratic, just and responsible city. Here he discusses the limits and dangers of new technologies. He identifies "that today's data and algorithms are inherently flawed or malicious – just as earlier technologies and scientific methods were not inherently flawed or malicious - but rather that ecological systems such as cities are far too complex to perfectly rationalize and that attempts to do so often create long-term damage" (Green, 2019, p. 144). He cautions that visions of science and technology as providing solutions that transcend history and politics to produce an optimal society, by building on examples of failure such as Le Corbusier's visions to new approaches to optimising forestry based on maths in Germany. Ultimately, Green calls for smart city policies that are a “means rather than an end”, driven by clear policy goals and long-term planning efforts when addressing technology based on five principles:

- Address complex problems rather than solve artificially simple ones (grasp complexity of urban issues, and integrated problems)
- Implement technology to address social needs and advance policy, rather than adapting goals and values to align with technology (smart city strategies should be the same as broader city strategies)
- Prioritize innovative policy and programme reforms above innovative technology (address local needs, adopt technology when impacts would be innovative also without the specific technology)
- Ensure that technology’s design and implementation promote democratic values (encounter information and power asymmetries and encounter smart cities as a cover tool for increasing surveillance, profits and social control)
- Develop capacities and processes for using data within municipal departments (lowering institutional barriers, identifying the problems that can be addressed)

These five principles confirm many of the barriers identified in this report for local authorities when linking information modelling to strategic planning. This literature reminds us that a core question is about the needs of planning departments, and problems instead of only enabling local authorities to be able to work with information modelling without knowing what the use of this is. It also raises the question about how to smartly amend administrative cultures and work processes.

2.2.3. BIM, CIM and urban planning

Previous research on the planning system and BIM highlighted that the planning system represents a promising vehicle for catalysing BIM uptake, and that, reciprocally, insights from BIM can provide decision support in the planning process, particularly in addressing housing needs (Allmendinger and Sielker, 2018). What BIM can do in the planning context is one of the fundamental issues that this research probes. A review of academic and grey literature reveals that much of the information about actual developments in BIM and planning comes from grey literature, and a large portion of the academic publications on BIM and planning is from conference papers. Together, this suggests BIM and planning is an emerging area for research, ripe for further exploration.

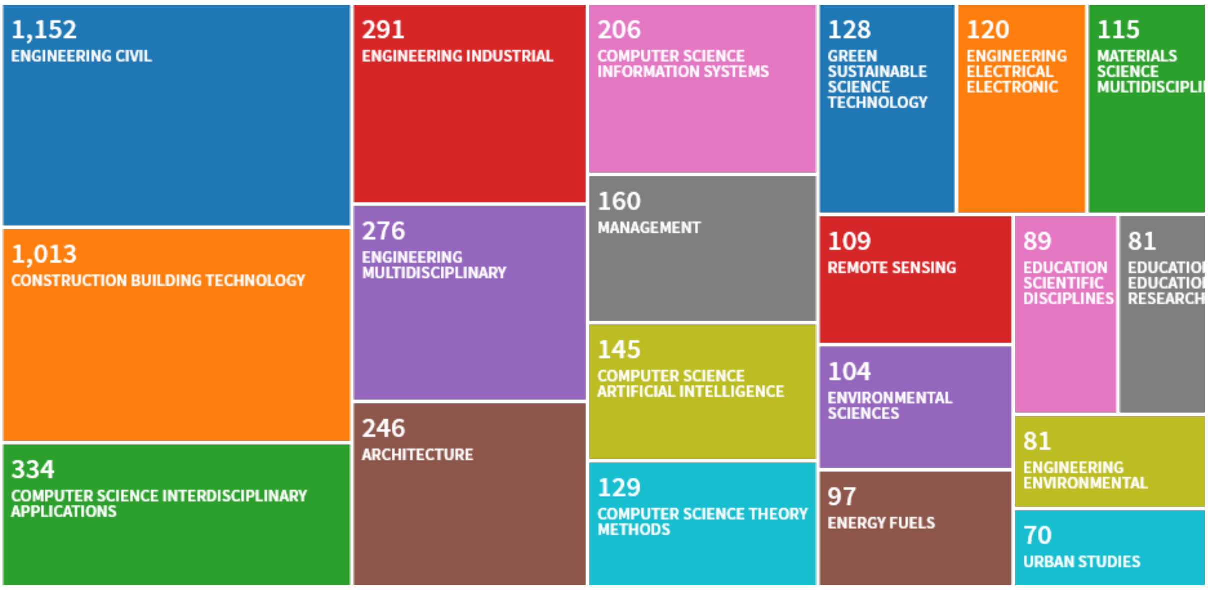
BIM has received a fair share of attention in journal publications in the last decade. Since 2009, there were more than 5,000 publications with the keyword BIM according to Web of Science; however, these publications are heavily concentrated in the engineering and construction industries. Urban studies barely makes it into the top 20 disciplines writing on BIM, and urban and regional planning is not represented at all. As this indicates, planning as an academic discipline has not engaged extensively with the subject of BIM, despite an overlap between BIM capabilities and common planning objectives.

The dearth of planning literature on BIM stands in stark contrast to the numerous publications on smart cities (compare Figure 10 with Figure 12). This indicates, paradoxically, that academics in planning and related fields are interested in smart cities, but have not yet focused on one of the technological tools capable of making cities smart.

City Information Modelling has received much less focus in academic journals, as compared to BIM and smart cities. Since 2009, there were only 16 publications on City Information Modelling, according to the Web of Science. The fields of urban studies, regional urban planning, geography and physical geography make relatively stronger showings than in the subject areas of BIM and smart cities, accounting for nearly 40 percent of the publications on CIM in the past 10 years. Yet, research still neglects these areas.

BIM, smart cities and CIM are highly relevant for planners, and as the analysis above indicates, there is a need for more engagement from the planning community. This project seeks to address the void, bringing a planning perspective to question around information modelling for planning our future cities. Much of the literature from urban studies and regional planning on BIM is of a technical nature, looking at integrating different types of geospatial data (see, e.g. (Anjomshoaa, 2014; Daum et al., 2017; Jusuf et al., 2017; Saran et al., 2018; Tah et al., 2017). This research, therefore, fills a gap, going beyond the technically possible to look at what is happening in practice.

Figure 12: Web of Science publications on building information modelling, by discipline, 2009 - February 2019



Source: own elaboration based on web of science.

Particularly when evaluating the grey literature, it can be difficult to distinguish between what has been done already and what could potentially be done in the future. Applications of BIM in planning contexts may be challenged by interoperability issues. Interoperability is the ability of a system or components of a system, to provide information portability across other systems or components. BIM deals with the micro real-world details of buildings' indoor/envelop data, using a local object/building coordinate system. However, planners and geographers often operate in Geographical Information Systems (GISs). GIS uses geographic coordinate systems to model outdoor real-world elements at the macro level at varying scales. Without full interoperability, BIM planning applications may be limited, because when researchers and practitioners attempt to merge BIM and GIS-based data, data can be degraded and lost. As of yet, there is no seamless way of integrating between GIS and BIM (Tah et al., 2017); however, the recent partnership between Esri, a leading GIS software provider, and Autodesk, a leading BIM software provider, shows great promise for the future.

Demonstrated uses of BIM in planning-related contexts

Visualisation

Some companies, such as True View Visuals, are creating on-site virtual reality experiences to show projects on location before they begin. The VR platform integrates with BIM to create a smooth workflow. The platform aims to aid contextual understanding to help planners, developers and communities make informed decisions about proposed developments (Future Cities Catapult, 2016).

Other companies are focused on web-based solutions, like Agency9, for example, which provides 3D visualisations of cities. Users can upload a variety of data types, including BIM, to be shared internally for project management purposes, or published publically. Agency9's particular solution is already in use in Nordic countries, helping visualise local plans and infrastructure projects. The platform has also been used to host consultations, in which participants are able to comment on the 3D model at different scales, ranging from details of architectural designs to entire local plans (ibid.).

Dassault Systems provided a planning focused example of a 3D model with their 3DEXPERIENCity® products, exemplary used in Virtual Singapore. This 3D Experience can be used for planning decisions, and for the visualisations of different scenarios.

Heritage Planning

Understanding and managing historical buildings can require multiple types of information, and so there have been a number of attempts to apply BIM to the task (Dore and Murphy, 2012; Saygi et al., 2013). These efforts have been somewhat limited by the lack of interoperability between BIM and GIS.

Managing Housing Stock

In North South Wales, the Department of Housing experimented with joining GIS-based data with BIM-based data to help it better manage its assets. Previously, it managed three separate datasets: one recording details of all its buildings and properties, one with details of tenants, one with drawing records of the buildings it owned, but these datasets were disconnected and recorded using different information systems (i.e. CAD and GIS). BIM solutions were proposed to help the Department of Housing match the dwellings it provides with the needs of its clients in an optimal way, but the project was challenged by interoperability issues between BIM and GIS (Zhang et al., 2009).

Building Permits

In the Netherlands, several SMEs collaborated to create a 3D city model and integrated several BIMs. Then, using clash detection software, the models were checked against local building regulations to see if they were compliant. If compliant, the researchers proposed that the design could then be uploaded to the building permit portal, which already accepts files in the format used by the experiment (van Berlo et al., 2013).

Flood Risk Management

There are some efforts to join BIM data with GIS-based data to facilitate detailed analysis of real buildings for flood damage assessment, which is a key component of modern flood risk management. The micro-level assessment proposed united complete building information (represented in BIM) with flood information (managed in GIS). As with other BIM application areas, this area is limited interoperability issues between BIM and GIS (Amirebrahimi et al., 2015).

Energy Planning

BIM can help with conducting sustainability analyses. In addition to supporting sustainable design during design and construction phases, BIM can also help with developing accurate energy estimates (Azhar and Brown, 2009). While sustainability analyses are frequently conducted and used by architects and contractors, these analyses could be useful in planning contexts.

Utilities

There has been some progress using BIM to monitor both interior utilities and public utilities; however, as is the case with many other applications, these applications have thus far been limited by interoperability issues (Hijazi et al., 2012).

View Coverage and Shadow Analysis

Research in the Netherlands shows that BIM can be used to determine things like the shadows cast by buildings and trees, and the amount of sunlight that rooftops get (Rafiee et al., 2014). This information can be use both for energy planning purposes, as well as supporting planning decisions around how development impacts on its surroundings in terms of view and shadow coverage.

Clearly, there is activity around applying BIM solutions to planning challenges. However, as the use cases above show, often these applications are limited by technical integration issues between BIM and other information systems. However, research in this area is quite active (see, e.g. Tah et al., 2017), and solutions are under development.

Possible Uses

There are some claims that people using City Information Modelling (CIM) can just drag and drop BIM projects into content-rich CIM models and find any data relevant for their project (Cityzenith, 2017). A review of the academic and grey literature about BIM's applications to planning challenges suggests that this level of seamless integration, enabling toggling from content-rich city to building-level models, is still in the realm of what we can imagine, and not yet in the realm of what we can do. However, as BIM technology progresses and interoperability issues between BIM and other systems are resolved, there will be increasing applications for BIM solutions in the planning process. A recent review of pain-points in planning revealed a number of places where BIM-enabled solutions could help facilitate the planning process (Future Cities Catapult, 2017). However, previously there was no whole-scale analysis done on what planners and stakeholders in the planning system seek to gain from a BIM-enabled digitalised tool. This research intervenes here to provide insight.

There is already movement towards creating a planning information model, which would unite the planning system with BIM (Future Cities Catapult, 2018) . The proposed planning information model project envisions, among other things, the potential to: automate the validation and policy fit analyses of planning applications; automate elements of preparing environmental and transport impact assessments; use data to make planning processes such as viability assessments and s106 requirements quicker and more transparent; provide richer data for conducting district and city forecasting; and greater certainty and higher level of detail for infrastructure providers on the impact of new development on their networks. Taken together, these interventions could make the planning process quicker, less costly, more transparent, and more adept at anticipating future needs, while placing citizens at the heart of planning.

2.2.4. Digital twins, big data and urban modelling

A further influential line of research focuses on the potential and the role of big data that are produced in the urban fabric, the role of augmented reality, 3D-visualisation and agent-based modelling, artificial intelligence, software developments and digital twins (see e.g. (Batty et al., 2012; Batty, 2013; Kitchin, 2014b, 2014a; Kitchin and Dodge, 2011; Kitchin et al., 2018; Komninos, 2015). This line of research is growing and has led to new research communities represented by, for example, the new Environment and Planning B Journal Urban Analytics and City Science or the new Data for Policy conference series.

As part of the 2018/2019 research projects funded by CDBB the projects of Timea Nochta (The local governance of digital technology – Implications for the city-scale digital twin) and Li Wan (A City-Level Digital Twin Experiment for Exploring the Impacts of Digital Transformation on Journeys to Work in the Cambridge Sub-region). Therefore, for a more extensive reading on digital twins we refer to these projects.

In short, and to give an idea of different digital twins, we build on Batty who has rightly summarised a shift from a definition of a digital twin as a digital reproduction of buildings, to a more complex understanding of 3D-models that can be combined to a digital representation of the built environment offering opportunities for scenario building and forecasting: "In strict terms, 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…. however, the concept has broadened and loosened somewhat in that it is now being applied, or rather used, to characterize a variety of digital simulation models that run alongside real-time processes that pertain to social and economic systems as well as physical systems." (Batty, 2018a, p. 817)

For the purpose of our research, we were interested in stakeholder's awareness of digital twins, city models and stakeholder's wishes to use these for urban planning. Digital twins, and different forms of urban modelling can play a major role for city planning. Combined with information modelling techniques the development of digital twins and city models can provide a new basis for urban planners and cities to rethink development strategies. Our main interest was to identify the potential use cases UK stakeholders envisage.

2.3. Data ethics, data sovereignty, responsible cities and empowering citizens

2.3.1. The legal right to privacy in the digital age

While at present most planning authorities that are looking at digitalisation are focused on linking up existing public datasets, authorities on the cutting edge of digitalisation are already considering ways to incorporate citizen data into their digital frameworks. Before sensors are introduced into our homes and streets, however, it is necessary to understand how this impacts on the human right to privacy, and our ability to access public spaces without constraint. The risks of data-fication in cities is not a new topic; and concerns around creating data-driven cities is also well documented (Batty, 2018b; Coletta et al., 2018). This includes questions about the use of multiple data-sets and data flows between different apps. It is, in particular, the multi-stakeholder relationships woven between citizen users, companies, and government that represents a nexus that is hard to govern (Komninos, 2014). In Europe the adoption about the EU General Data Protection Regulation (GDPR) has put these concerns to the forefront of public debate (Murphy, 2018).

The human right to privacy is well established, and extends to citizens' online presence (see Table 2). Privacy has been formally recognised as a human right since 1948, when the United Nations included it in the Universal Declaration of Human Rights (Diggelmann and Cleis, 2014). In 2013, the UN affirmed that people's right to privacy applies online, just as it does offline (United Nations). Several years after the UN recognised the human right to privacy, the Council of Europe followed suit with the European Convention on Human Rights in 1953, which also affirms that privacy is a human right. Later, the UK adopted legislation recognising privacy as a human right in the Human Rights Act, 1998. Most recently, in 2018, the UK passed legislation to enact the EU General Data Protection Regulation (GDPR), which stipulates the ways in which personal data must be treated, providing further protection for privacy in a digital age. With the human right to privacy well established in legal doctrine, it is clear that local authorities and national governments must take steps to ensure that citizen data from the built environment is used with the utmost care, and that the impetus to gain insights from data analysis does not slide into illegal surveillance.

As Zuboff (2019a) argues, the current paradigm for privacy protection when interacting with objects from the Internet of Things does not actually protect the privacy of individuals, and can amount to corporate surveillance of individuals. As we argue in section 4.6.5, this model is not appropriate for data collected from the built environment.

Table 2 Legal Protections for Privacy as a Human Right

Name	Creator	Year	Relevant Text or Summary
Universal Declaration of Human Rights	United Nations	1948	No one shall be subjected to arbitrary interference with his privacy, family, home or correspondence, nor to attacks upon his honour and reputation. Everyone has the right to the protection of the law against such interference or attacks (United Nations, 1948)
European Convention on Human Rights	Council of Europe	1953	1. Everyone has the right to respect for his private and family life, his home and his correspondence. 2. There shall be no interference by a public authority with the exercise of this right except such as is in accordance with the law and is necessary in a democratic society in the interests of national security, public safety or the economic well-being of the country, for the prevention of disorder or crime, for the protection of health or morals, or for the protection of the rights and freedoms of others (Council of Europe, 2010)
Human Rights Act	United Kingdom	1998	1. Everyone has the right to respect for his private and family life, his home and his correspondence. 2. There shall be no interference by a public authority with the exercise of this right except such as is in accordance with the law and is necessary in a democratic society in the interests of national security, public safety or the economic well-being of the country, for the prevention of disorder or crime, for the protection of health or morals, or for the protection of the rights and freedoms of others (UK Government, 1998).
UN Resolution 68/167	United Nations	2013	Affirms that the same rights that people have offline must also be protected online, including the right to privacy (Office of the United Nations High Commissioner for Human Rights, 2014)
GDPR (General Data Protection Regulation)	European Union	approved 2016, enforced 2018	GDPR replaced the Data Protection Directive 95/46/EC and includes rules for companies and rights for citizens. The main goal was to provide a harmonised data privacy laws in the EU for citizens in order to protect citizen from data breach, and thereby to reshape the way organizations across the EU deal with data privacy. A major change was that GDPR applies to the processing of personal data of EU citizens independent whether the processing of personal data takes place in the EU or not. Consent must be easily understood by citizens. The regulation entails a number of more detailed aspects ranging from consent-giving, accessibility of understanding, right to access, right to be forgotten, data portability, introduces penalties, and requires data authorities (European Commission, 2018) *
Data Protection Act	United Kingdom	2018	Everyone responsible for using personal data… must make sure the information is: used fairly, lawfully and transparently; used for specific, explicit purposes; used in a way that is adequate, relevant and limited to only what is necessary; accurate and, where necessary, kept up to date; kept for no longer than is necessary; handled in a way that ensures appropriate security, including protection against unlawful or unauthorised processing, access, loss, destruction or damage.... you have the right to…: be informed about how one's data is being used; access personal data; have incorrect data updated; have data erased; stop or restrict the processing of one's data; data portability, allowing one to get and reuse one's own personal data for different services; object to how one's data is processed in certain circumstances (UK Government, 2018)**

*This text summarises key elements

**This text is taken from the UK Government website's page about the Data Protection Act because it is more concise than the legal text

Source: own elaboration

2.3.2. A digital Built Britain: The Gemini Principles supporting data management

The Gemini Principles, developed by the Digital Framework Task Group under the auspices of CDBB, provides a roadmap to guide the development of an information management system to help unlock the full power of the built environment's information value chain (Bolton et al., 2018). The Principles offer foundational guidance to ensure that the system built to manage the information flowing from the built environment to assist decision-makers is purposeful, trustworthy, and functional over time and across sectors. Though designed to support the construction of an information management system for a national digital twin (NDT), the Gemini Principles provide fundamental guidance for information modelling systems for the built environment at any scale, including BIM and CIM. An NDT will include digital twins of buildings and other assets in the built environment, so BIM and CIM will represent some of its constituent parts. As such, the same information management system principles that apply to the NDT also apply to BIM and CIM, offering a framework for addressing questions about who benefits from data usage, data ownership, and the responsibilities of data owners, users, and the government to ensure privacy and security.

Figure 13: The Gemini Principles

Source: Bolton et al., 2018

Purpose

Gemini Principles one through three respond to questions about the purpose of information management systems: they should deliver inclusive public good in perpetuity, and data that does not create demonstrable value should not be aggregated and used. Read in light of the right to privacy in the digital age, this principle provides a litmus test for data usage: if data does not provide "inclusive social outcomes" and "determinable insight into the built environment" (Bolton et al., 2018, p. 18) it likely should not be included in BIM and CIM systems.

This principle also provides insight for questions about how private companies in the UK should be able to use and profit from city data: private companies that rely on BIM and CIM-level data should be providing demonstrable and inclusive public good through their usage.

Trustworthiness

Gemini Principles four through six relate to trust. The public and other information management system stakeholders must be able to trust information management systems. Information management systems, including at BIM and CIM levels, must be ethical and secure by design, and the governance and regulatory arrangements for overseeing them must be transparent, open and address issues of liability and risk. Information management systems must strike a balance, capturing the network effects that come from when more people use, contribute to and maintain data, while also mitigating against security risks and privacy violations.

To protect privacy and data security, the UK needs policies and monitoring and enforcement mechanisms for information modelling systems. At the urban scale, cities around the world are experimenting with such policies and mechanisms. International approaches to questions of privacy and security at the urban scale are detailed in the section on International examples below.

Function

Gemini Principles seven through nine relate to function, addressing interoperability, data ownership, and governance. Information management systems must be based on standard, collective and connected environments that enable secure and resilient data sharing. Though not prescriptive about who should own data, the Principles hold that ownership must be transparent and clear, and assert that governance should ensure fair value share, including to the end-users. Studying smart city experiments around the world, covered in the section below on International examples of data management highlights the complexity and importance of data ownership and delivering fair value share.

International examples of data management

Cities all over the world are eager to claim the smart city moniker, and many are implementing plans for digitalising their urban infrastructure. Digital cities take different approaches to data management, and have different solutions to questions of privacy, data sovereignty, and socially responsible data-enabled urban development. Two European examples, Amsterdam and Barcelona, are actively pursuing data management initiatives that attempt to put citizens in control of their data. Both these cities are pilot sites for the ‘Decentralised Citizen Owned Data Ecosystems’ (DECODE) initiative. DECODE, which began in 2017, is an initiative to provide tools that put individuals in control of whether their personal information is kept private or shared for the public good, funded by the European Commission’s Horizon 2020 research and innovation programme. This is a different approach to urban data use than the one currently in use in the development of the Quayside area in Toronto, a project driven by Alphabet subsidiary Sidewalk Labs. As the Quayside development is happening in a different context and with partial private company funding, the processes and outcomes of data management discussions are different, though there are some commonalities with initiatives in Barcelona and Amsterdam. Notably, none of the three cities mentioned above have explicitly planned for BIM, CIM, or NDTs, so there are as of yet few examples for how socially responsible cities can approach data use in information modelling on a large scale.

2.3.3. Scholarly reflections on data ethics and dealing with privacy: the Right to the smart city

The above section illustrated the legal background of data privacy, and gave some examples for international approaches to dealing with data ethics. In general, data privacy, surveillance and ethics are covered in smart city, AI and IoT literature. In this specific section, we examine two approaches that present the role of privacy in structured way.

Since the rise of the smart city agenda, there have been calls for a bottom-up approach, involving citizens and a broad set up of stakeholders, driven in part by concerns about data privacy, which have dominated much of the public debate. Cardullo et al. (2019) call for a meaningful engagement of key stakeholders with questions around respect to rights, citizenship, social justice, commoning, civic participation. Cardullo et al. further call for humanising the urbanisation processes and the city (2019).

Privacy can be defined as “to selectively reveal oneself to the world” (Hughes, 1993) and is considered a basic human right in many jurisdictions, enshrined in national and supra-national laws in various ways. At the same time, privacy is understood as an everyday and a legal concept, which varies between cultures and contexts.

The challenge for public authorities lies not only in the complex legal landscape, but also in a comprehensive approach to privacy. We present three different approaches to privacy models, which may support local authorities in creating privacy strategies (for more on privacy, see section).

A first consideration asks who is involved. Kitchin provides a good overview of involved stakeholders (2016a).

a. — utility companies (use of electricity, gas and water);
b. — transport providers (location/movement, travel flow);
c. — mobile phone operators (location/movement, app use and behaviour);
d. — travel and accommodation websites (reviews, location/movement and consumption);
e. — social media sites (opinions, photos, personal information and location/movement);
f. — crowdsourcing and citizen science (maps, e.g. OpenStreetMap; local knowledge, e.g. Wikipedia; weather, e.g. Wunderground);
g. — government bodies and public administration (services, performance and surveys);
h. — financial institutions and retail chains (consumption and location);
i. — private surveillance and security firms (location and behaviour);
j. — emergency services (security, crime, policing and response); and
k. — home appliances and entertainment systems (behaviour and consumption).

The list above indicates the complexity of stakeholders that are concerned by and must be involved in privacy strategies, taking account of the legal situation.

A key question for these stakeholders is around what types of privacy breaches they can suffer. In the same article as above, Kitchin provides a taxonomy of privacy breaches, that smart city developments, and therefore BIM users as well, are well advised to be aware of (Kitchin, 2016b):

Table 3: A taxonomy of privacy breaches and harms

Process	Privacy breach	Description
information collection	surveillance	watching, listening to, or recording of an individual's activities
	interrogation	various forms of questioning or probing for information
information processing	aggregation	the combination of various pieces of data about a person
	identification	linking information to particular individuals
	insecurity	carelessness in protecting stored information from leaks and improper access
	secondary use	use of information collected for one purpose for a different purpose without the data subject's consent
	exclusion	failure to allow the data subject to know about the data that others have about her and participate in its handling and use, including being barred from being able to access and correct errors in that data
information dissemination	breach of confidentiality	breaking a promise to keep a person's information confidential
	disclosure	revelation of information about a person that impacts the way others judge her character
	exposure	revealing another's nudity, grief, or bodily functions
	increased accessibility	amplifying the accessibility of information
	blackmail	threat to disclose personal information
	appropriation	the use of the data subject's identity to serve the aims and interests of another
	distortion	dissemination of false or misleading information about individuals
invasion	intrusion	invasive acts that disturb one's tranquillity or solitude
	decisional interference	incursion into the data subject's decisions regarding her private affairs

Source: Kitchin 2016, compiled from (Solove, 2013)

In a similar vein, Martinez-Balleste et al. (2013) summarize example for privacy concerns and suggest solutions according to five strategies: identity, query, location, footprint and owner (Table 4).

Table 4: Privacy concerns

Our 5D approach	Mapping to existing models		Examples of privacy concerns	Existing solutions
	3D database	W3 LBS		
Identity		Who	Most of the examples entail identity privacy concerns. RFID and video surveillance are also related to identity issues.	Pseudonymizers, RFID privacy techniques, privacy-aware video surveillance
Query	User	What	Mainly location-based services, interactive information poles, etc.	Private Information Retrieval techniques, random pseudonymizers
Location		Where	Location-based services, other services involving location (for example, smart parking). Also video surveillance entails location privacy.	Collaboration for location masking, cloaking, pseudonymization, privacy-aware video surveillance
Footprint	Respondent		Microdata generated from a variety of sources (sensors, RFID readers, medical data, electronic voting, etc.)	Anonymization, Statistical Disclosure Control
Owner	Owner		Obtaining information across databases belonging to different entities.	Privacy-Preserving Data Mining, Statistical Disclosure Control

Source: (Martinez-Balleste et al., 2013)

In the context of managing vast amounts of data collected and stored in different databases, Domingo and Ferrers differentiation of respondent, user and owner privacy can be a good approach to address privacy considerations (Table 5).

Table 5: Privacy Differentiation

Respondent privacy	This is focused on avoiding the re-identification of individuals (i.e., respondents) whose information is stored in a database. This can relate to engagement with social networks or other location-based service (LBS) providers. These data are stored in the databases of the service providers and can be analysed to obtain a variety of information. Regarding respondent privacy, no sensitive or private information should be leaked from these databases. They must be protected before being published or released to third parties. Statistical disclosure control (SDC) is usually used to do so.
User Privacy	This is about guaranteeing the privacy of the queries made by a user to a database system (e.g., Internet search engines, LBS providers). The point is to obtain the desired information without revealing the real query to the database system. This is known as the private information retrieval (PIR) problem. In this example, the queries made by the user to the LBS provider should follow a protocol to prevent the provider from learning them.
Owner Privacy	This privacy dimension refers to the owner of a database queried by other users/entities. The owner might agree to share some of her data, but it should be controlled so that only those data (and no more) are gathered by the issuers of the queries. The privacy preserving data mining (PPDM) discipline designs techniques to address this problem. In this example a third party (a data warehousing facility) pays an LBS provider and a social network to mine their data. In this case protecting owner privacy means allowing the third party to access the information he paid for but no more.

Source: Martinez-Balleste et al. 2019

3. Methodological approach and structure of work

The research is located in the fields of urban studies and planning and makes use of methods common in the humanities and social sciences. We used a mixed methods approach in this research, relying on desk-based policy analysis, statistical analysis, case studies, interviews, and a questionnaire. To understand the constraints to implementing information modelling for planning, one must look at the contexts in which planning takes place. This includes analysing the local as well as the legal contexts. As planning remains in the jurisdiction of the devolved Nations, the UK literature analysis and case studies reflected two nations of the UK, in this case the English and the Scottish systems.

3.1. Structure of work

The project has been delivered through six work packages. The work packages reflect both project management, and the different methodological steps and main areas of research around barriers to BIM, smart cities and CIM, and the questions around privacy social responsibility when dealing with BIM.

The first work package included the literature and document analysis for the development of a conceptual framework to identify barriers to information modelling in planning. The second work package focused on the case studies, as well as on conducting complementary interviews to identify stakeholders' perspectives on BIM. The third work package focused on the development and the analysis of a questionnaire to complement the analysis of the interviews and case studies. The fourth work package aimed to focus on cities' social responsibility when dealing with data, and the legal background. The fifth and sixth work package focus on the project administration, and the reporting and dissemination (Table 6).

Table 6: Work packages and structure

Conceptual framework	**WP 1**	**Smart cities, urban planning and CIM**
	WP 1.1	Literature database and analysis
	WP 1.2	Policy document analysis
	WP 1.3	Development of conceptual framework
Empirical case studies	**WP 2**	**Case Studies: Identifying and solving barriers**
	WP 2.1	Case study selection
	WP 2.2	Cambridge (as an example for a complex city governance and devolution, and a representative of fast-growing cities)
	WP 2.3	Bristol (as an example for a metropolitan area and a leading UK smart city strategist, as well as an example or revitalisation efforts)
	WP 2.4	Scotland (as an example for rural communities and multi-level governance)
	WP 2.5	Comparative analysis and complementary interviews
Wider empirical reflection	**WP 3**	**Questionnaire: Solving barriers**
	WP 3.1	Development of questionnaire
	WP 3.2	Implementation of questionnaire
	WP 3.3.	Analysis of questionnaire
	WP 3.4	Data management
Reflection & discussion	**WP 4**	**Reflection: Social responsibility, accountability and future city planning**
	WP 4.1	Social, legal and political perspectives
	WP 4.2	Recommendations and conclusions
Project administration and meetings	**WP 5**	**Project administration, management and meetings**
	WP 5.1	Meetings (monthly project meetings and bimonthly ECR meetings)
	WP 5.2	Project management and administration (ongoing)
Reporting and deliveries	**WP 6**	**Reporting, deliveries and dissemination**
	WP 6.1	Interim reports
	WP 6.2	Final report
	WP.6.3	Dissemination activities (posters, conference presentations, working paper)
	WP 6.4	Webpage and blog articles (ongoing)

3.2. Document and literature analysis

The document and literature analysis focused on a variety of topics in line with the projects design, including:

1. Literature review of academic literature and grey documents on smart city developments, digitalisation of urban planning, BIM, city information modelling and digital twins

2. Literature analysis and policy document analysis of **England's and Scotland's planning systems**. Scotland is currently in a phase of review of its approach to planning and has developed a Digital Task Force, which we explored further through interviews
3. Review of literature on digitalisation in planning in the UK
4. Literature review and policy document analysis of the **legal background of the right to privacy** and opportunities for socially responsible smart city development.
5. Policy document analysis of the contemporary planning challenges, approaches and issues in **the case of Cambridge**
6. Policy document analysis of the contemporary planning challenges, approaches and issues in **the case of Bristol**
7. Policy document analysis of the contemporary planning challenges, approaches and issues in **the case of Scotland**
8. Preparation of stakeholder interviews.

Over the project period, literature and document analysis gave background to each work package, therefore is the methodological backbone to the work. For a non-exhaustive list of documents consulted, see Annex I: Table of planning-related documents. The literature was collected in a databank using Zotero.

3.3. Case studies and local authority typology development

Local authority typologies and case study selection

A core element of this research was the analysis of three case studies across the UK. In our case study approach, we aimed to reflect different geographical areas, with different governance structures, and different socio-economic and demographic trends. We applied five criteria for the selection of case studies: (1) diversity of socio-economic contexts, (2) size of settlements and planning challenges, (3) diversity of governance arrangements, (4) representation of the UK's planning systems, (5) willingness of key stakeholders in the case study regions to contribute.

❖ Diversity of socio-economic contexts and growth trajectories

Spatial development dynamics vary considerably, and are often influenced by wider societal, economic and locational trends. This research conducted a socio-economic analysis of four indicators

- Balanced GVA per head
- 10-year GVA growth rate
- 10-year population growth rate
- Old-age dependency ratio.

The later three indicators have been combined into a composite growth indicator to better understand the combined impacts of the different development trajectories on individual local authorities.

This analysis aimed to ensure understanding of the diversity of socio-economic backgrounds of each local authority, which impacts on local authorities' financial capacities as much as on their planning challenges.

❖ Size of local authorities and planning challenges

Spatial development trends and planning challenges differ considerably between local authorities. These are dependent on socio-economic development trends, and whether cities are, for example, growing or stagnating or even declining. Development paths may therefore prompt local authorities to develop plans to steer growth, develop regeneration strategies, or manage de-growth. Spatial development trends differ between settlements of different sizes, and change depending on cities' role in the local authorities in the surrounding areas. The density of settlements and path dependent development trends also impact on planning contexts. The potential uses of information modelling and the capacity of cities to engage with digital tools is strongly dependent on these aspects

We used the "representative type of settlement" indicator to characterise UK settlements (see section 4.1.1), and considered different planning challenges when selecting case studies.

- Diversity of governance arrangements

Apart from the diversity of spatial development dynamics, differences in governance structures can pose an additional challenge to the take up of information modelling. This research aims to consider the impact of different governance arrangements. The selected case studies reflect a diversity of local authorities. In addition to the more in-depth case studies, the research further examined other local contexts. For example, smart city approaches and digital twin development in Liverpool were discussed. In the third case study in Scotland, we included several local authorities in the interviews phase.

- Representation of the UK's different planning systems

A third criterion is that at least two of the four of the UKs nations and planning systems shall be represented. Scotland and England do not only represent the largest number of UK local authorities, they also represent two different approaches to planning (see section 2.1 Background on UK planning systems).

- Willingness of key stakeholders in case study regions to engage

A prerequisite for qualitative research, as applied in this project, is the willingness of key stakeholders to take time for expert interviews, and give excess to documents, which are not necessarily available on webpages. Therefore, willingness to engage was part of our selection criteria. Sections 4.1 and 4.2 below introduces the statistical analysis, and the case studies selected.

Case study implementation and stakeholder interviews

Using the contextual understanding developed through the case study selection process (explained in more detail below) as well as additional desk-based research on important local developments, we conducted 45 semi-structured stakeholder interviews across the UK. Although the majority of stakeholders interviewed were tied to one of the three case studies, we also interviewed representatives from housing associations, large AEC companies, BIM-oriented academics, as well as representatives from several other local councils to add breadth and depth to the analysis. A full list of the organisations from which we interviewed representatives can be found in Annex II: List of organisations interviewed. For the interviews, we targeted stakeholders involved with and impacted by the planning system. We selected interviewees based on a combination of intentional selection and snowballing.

Every stakeholder interview was different and questions were targeted towards individual context. Consistent across all interviews, however, was a focus on identifying: opportunities in the planning system for how information modelling can improve planning outcomes; the barriers planning practitioners, housing developers and other stakeholders in the built environment encounter in the process of digitalisation; stakeholder knowledge of BIM; and solutions for overcoming the barriers identified. Additionally, all interviews focused on eliciting a wish list from stakeholder regarding what actions they desired from government to help overcome barriers to information modelling in planning.

Analysis of case studies and reflection

Stakeholder interviews were transcribed through an external service and analysed using qualitative content analysis with the help of the software atlas.ti. For the qualitative data analysis, we coded the interviews. We used a set of 95 codes to analyse the interviews. The codes were iteratively developed to reflect the themes that emerged in the interviews. Analysis focused on drawing out barriers to implementing information modelling in planning, opportunities for information modelling in planning and recommendations for tactics and policies to help overcome barriers.

Based on the literature review and the analysis of the stakeholder interviews an analytical-conceptual framework was developed to structure the barriers into six categories, which then guided the further analysis.

3.4. Questionnaire

The analysis of case studies was complemented through the analysis of a questionnaire involving stakeholders across the built environment.

We distributed a questionnaire to planning stakeholders across the UK. The aims of the questionnaire were fourfold:

1. Gauge stakeholder awareness around information modelling and its uses
2. Triangulate findings from interviews about the barriers to information modelling implementation for planning
3. Triangulate findings from interviews about opportunities to use information modelling in support of planning
4. Develop recommendations for solutions to promote implementation of information modelling for the planning system

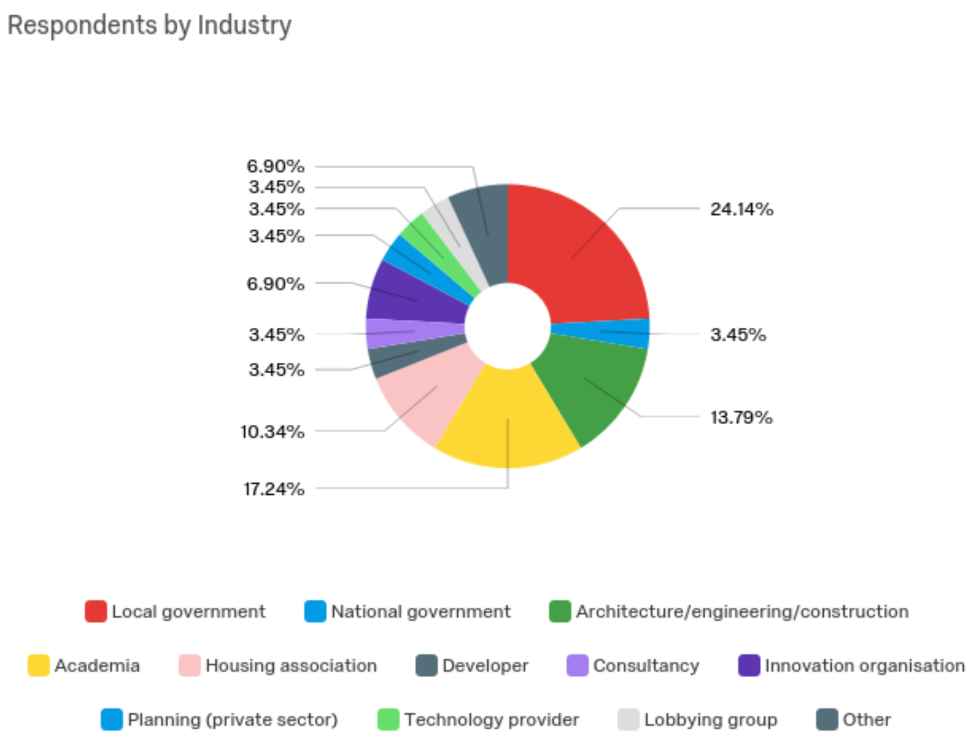
We distributed the questionnaire broadly to stakeholders involved with the planning system in the UK. We distributed the questionnaire through the project's webpage, through the CDBB newsletter, by advertisement at conference presentations, through social media platforms such as twitter as well as through the CDBB housing network. The survey received 32 responses, spread across the industries and geographies as shown below (Table 7 and Figure 14). There is likely a bias in our results, as those with an understanding of and interest in information modelling are more likely to respond to the survey, and our sample size was relatively small. However, overall, the results provide valuable insights and confirmed information received through the interviews. The questionnaire offered a better understanding of where stakeholders from different spheres agree or disagree.

Table 7: Geographical region of operation

Geographic region	%	Count
England	44.83%	13
Scotland	17.24%	5
UK-wide	17.24%	5
Europe (continental)	3.45%	1
Europe and the UK	13.79%	4
North America	3.45%	1
Total	**100%**	**29**

Source: own elaboration

Figure 14



Source: own elaboration

4. Analysis and discussion

This section provides first an overview of the diversity of the UK's local authorities, and how the methodology described above was applied to create a typology to analyse local authorities, which ultimately informed the case study selection process. The presentation of the case studies offers insight into their local contexts and introduces the case study narrative. In the third part of this section, we present findings showing stakeholder's current awareness of information modelling. In the fourth section we present opportunities implementing information modelling for planning, drawing on stakeholders' visions and wishes for potential future applications. In section 4.5, we analyse in detail the barriers that would need to be overcome to take advantage of the opportunities for implementing information modelling. Following this detailed analysis, in which we draw on the interviews and the questionnaire, we then identify potential ways to address the barriers. Finally we develop preliminary recommendations, and highlight the role of the right to privacy.

4.1. Building a typology to categorise local authorities

To categorise local authority growth potential and current demographic characteristics, we developed a typology, combining data on local authority size, demographic characteristics and economic indicators. Specifically, the typology considered:

i. the value of the local authority's economy as measured by gross value added (GVA), the measure of the value of goods and services produced in an area;
ii. the local authority's population size; and
iii. a composite index we created to capture the local authority's growth trajectory, which looks at population and economic growth rates, and population age dynamics, as measured by Old Age Dependency Ratio

This typology provided input to our case study selection process. After conducting a statistical analysis on demographic and economic trends, we then considered factors related to spatial development trends, planning challenges, government structures, planning systems, and willingness to engage with this research (see section 4.1.4). We sought to select a diverse range of case studies, as areas are likely to face different challenges to and opportunities for using information modelling in planning depending on factors such as the current value of the economy, its current population size, and the local authority's growth trajectory as related to its future prospects for economic and population growth.

4.1.1. Type of settlement

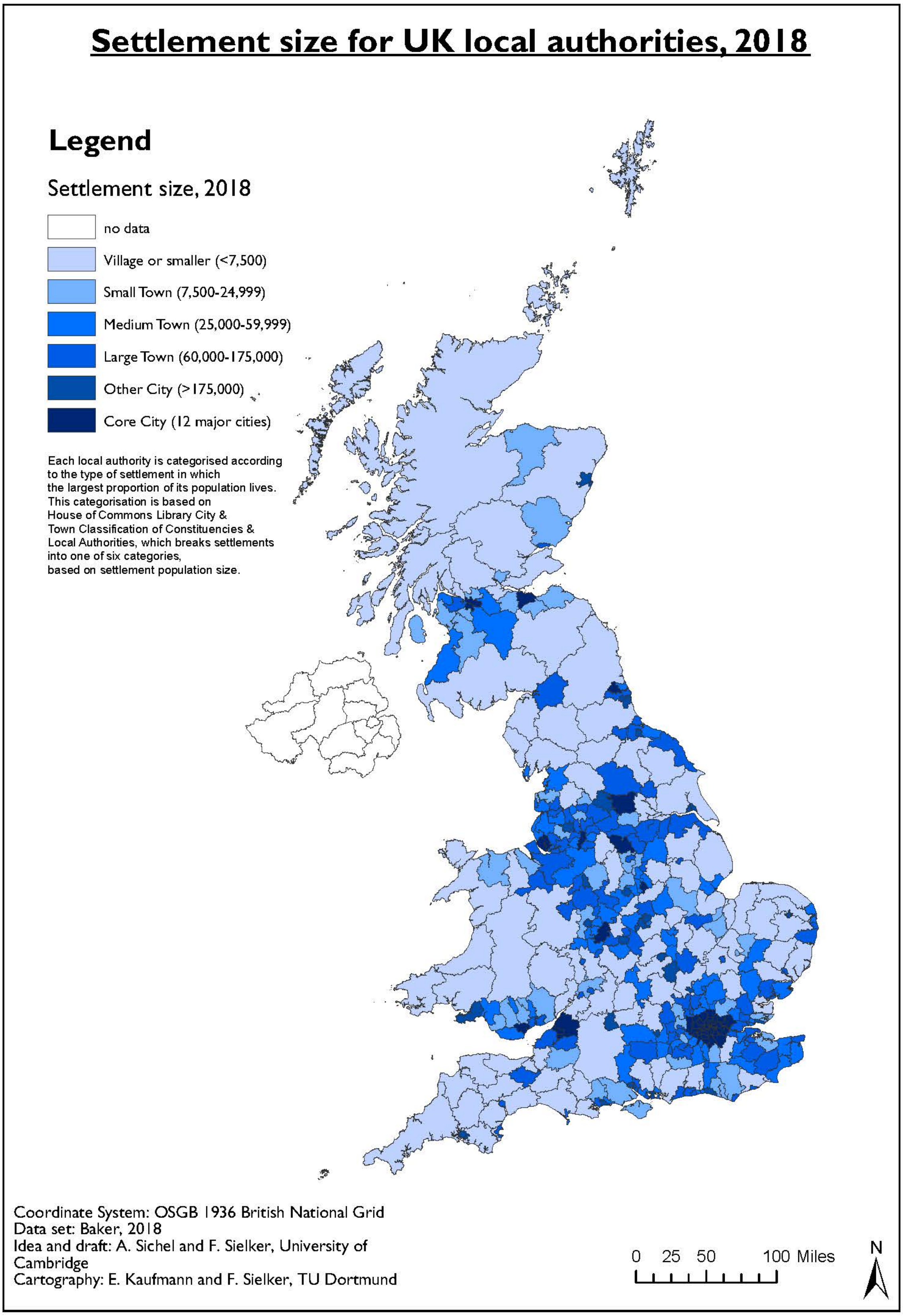
Simply comparing the population sizes of different local authorities is not a good way to understand the types of settlements contained in the authority. For example, a local authority that covers a large geography may have a comparatively large population, but may be sparsely settled. The opportunities for and barriers to information modelling for planning in a sparsely settled rural community are likely to be different to those in more densely populated metropolitan area. Therefore, this analysis relied on the City and Town Classification of Constituencies and Local Authorities developed for the House of Commons Library (Baker, 2018). This classification system categorized each local authority according to the type of settlement in which the largest proportion of its population lives. Possible classifications include "Core Cities", defined as "the principal cities of their city regions, hosting high-level services and anchor institutions that attract investment and people" (Pike et al., 2016); "Other Cities", which are other settlements with a population of more than 175,000; "Large Towns" which are settlements with a population between 60,000 and 174,999, "Medium Towns", settlements with a population between 23,000 and 59,999, "Small Towns", settlements with a population between 7,500 and 24,999; and villages and small communities, settlements with a population of less than 7,500 (Table 8). Figure 15 below illustrates the representative settlements sizes across the UK.

Table 8: City and Town Classification of Local Authorities

Category Name	Definition	Number of Settlements in UK
Core Cities	Principal cities of their regions with high-level services and anchor institutions to attract people and investment	12
Other Cities	other settlements with a population of more than 175,000	24
Large Towns	settlements with a population between 60,000 and 174,999	119
Medium towns	settlements with a population between 25,000 and 59,999	270
Small Towns	settlements with a population between 7,500 and 24,999	674
Villages and Smaller Communities	settlements with a population of less than 7,500	6116

The spatial distribution shows a clear development corridor of cities between the Dover coasts, London towards the areas of Birmingham, Manchester, Liverpool and Newcastle, which represent the Northern Powerhouse. The Bristol area is an important growth area to the West. The settlement density and the population size and importance of the city give a good background to understand the overall city network and the role of local authorities when approaching planning.

Figure 15



4.1.2. Economic prosperity

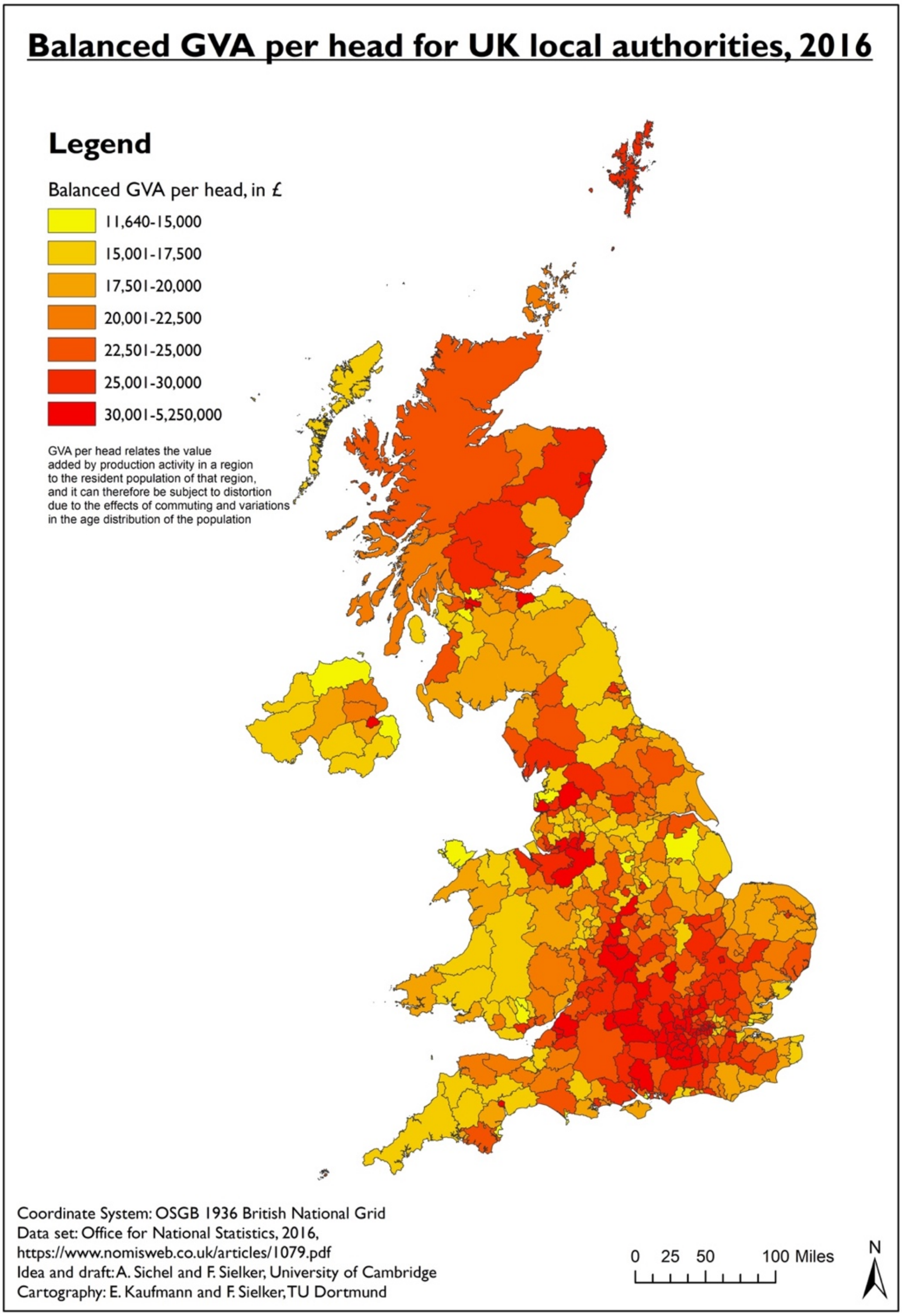
To capture a measure of the size of the local authority economy in relation to the resident population there, we used Balanced GVA per head, taken from Office of National Statistics from 2016, as at the time of this analysis those were the most recent figures available. This metric was used to account for the current value of local administrative units' (LAUs) economies. The average GVA per head in the UK was £37,907. To develop a local authority typology, we divided LAUs into terciles based on their GVA per head value. The third tercile, which includes LAUs with the lowest GVA per head, ranged from £11,640 to £19,190, the middle tercile went from £19,191 to £24,845 and the final tercile went from £24,846 to £5,229,716 (this is for the City of London). Based on those categories, we created a relative scale, ranking those LAUs in the third tercile as being low prosperity areas, those is the middle tercile being moderate prosperity areas, and those in the first tercile being high prosperity areas

Table 9 Local authority typology categorisation – economic prosperity

GVA per head	Category
£24,846 to £5,229,716	High prosperity
£19,191 - £24,845	Moderate prosperity
£11,640 - £19,190	Low prosperity

While this rough categorisation misses nuances between localities, and is relative to the UK, it provided a good understanding regarding how prosperous LAUs were, in comparison to each other. Figure 16 below illustrates the distribution of GVA per head in local authorities across the UK.

Figure 16


Balanced GVA per head for UK local authorities, 2016
Legend
Balanced GVA per head, in £
11,640-15,000
15,001-17,500
17,501-20,000
20,001-22,500
22,501-25,000
25,001-30,000
30,001-5,250,000
GVA per head relates the value added by production activity in a region to the resident population of that region, and it can therefore be subject to distortion due to the effects of commuting and variations in the age distribution of the population
Coordinate System: OSGB 1936 British National Grid
Data set: Office for National Statistics, 2016,
https://www.nomisweb.co.uk/articles/1079.pdf
Idea and draft: A. Sichel and F. Sielker, University of Cambridge
Cartography: E. Kaufmann and F. Sielker, TU Dortmund
0 25 50 100 Miles
N

4.1.3. Growth potential

To understand a local authority's development trajectory, indicators important to the local authority's growth potential were combined into an unweighted, composite index: the composite Growth Potential Index. The indicators considered were the LAU's 10-year GVA growth rate, the 10-year population growth rate, and the area's Old Age Dependency Ratio, which is the number of people over 65 years old for every 1,000 people aged between 16 and 64 years old,. The GVA and population growth rates were calculated using Office for National Statistics figures from 2007 to 2016. The Old Age Dependency Ratio was taken from Office of National Statics records from 2017. In the section below, we first analyse each indicator in the Growth Potential Index separately, before presenting the Growth Potential Index and its results.

To create the Growth Potential Index, LAUs were given scores between 1 and 10 for each indicator. The scores were determined by what decile the LAU fell into for each of the three indicators. Cities in the top decile for an indicator received a score of 10 for that indicator, and those in the bottom received a score of one. The raw scores for each indicator for a LAU were then added, divided by the total potential score of 30, and multiplied by 100 to give a composite growth potential index rating between 10 and 100, which takes into account previous economic and population growth trends, as well as demographic trends relating to aging populations. For example, Milton Keynes, which was in the top decile across all indicators (indicating high 10-year GVA and population growth rates and a low Old Age Dependency Ratio), received a score of 100, while the Isle of Anglesey, which scored in the lowest decile across all indicators, received a score of 10.

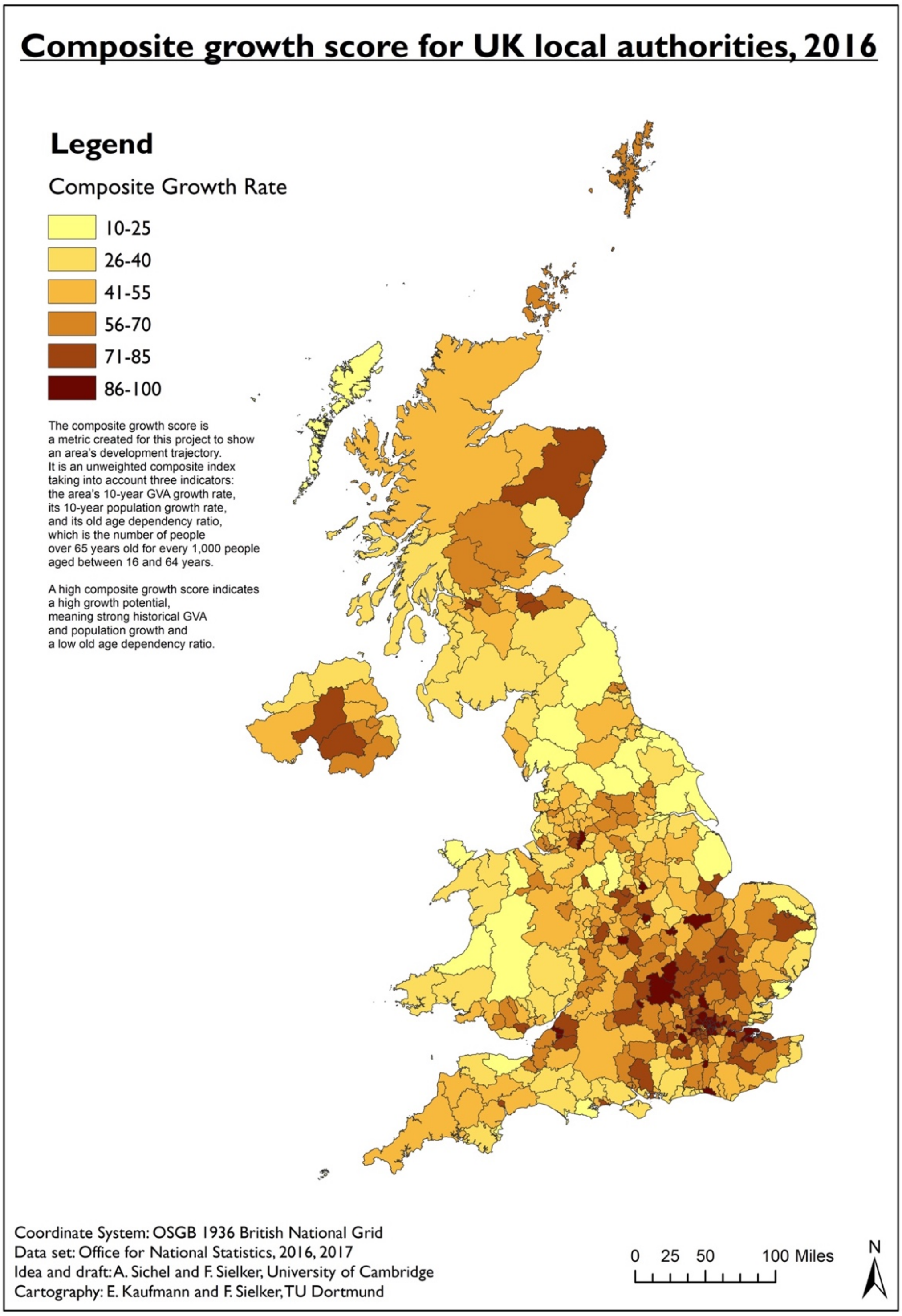
Similar to the way in which we categorised local authorities' economies based on comparing them to other local authorities, we also categorised local authorities by their Growth Potential Index score. Those in the top tercile (64-100) were consider to have fast growth potential; those in the middle tercile (46-63) were considered to have moderate growth potential, and those in the third tercile (10-45) were considered to have slow/declining growth potential.

Table 10 Local authority typology categorisation – growth potential

Growth Potential Index Score	Category
64-100	Fast
46-63	Moderate
10-45	Slow/declining

Figure 17 illustrates how growth potential, as measured by the growth potential index, is distributed across the UK.

Figure 17

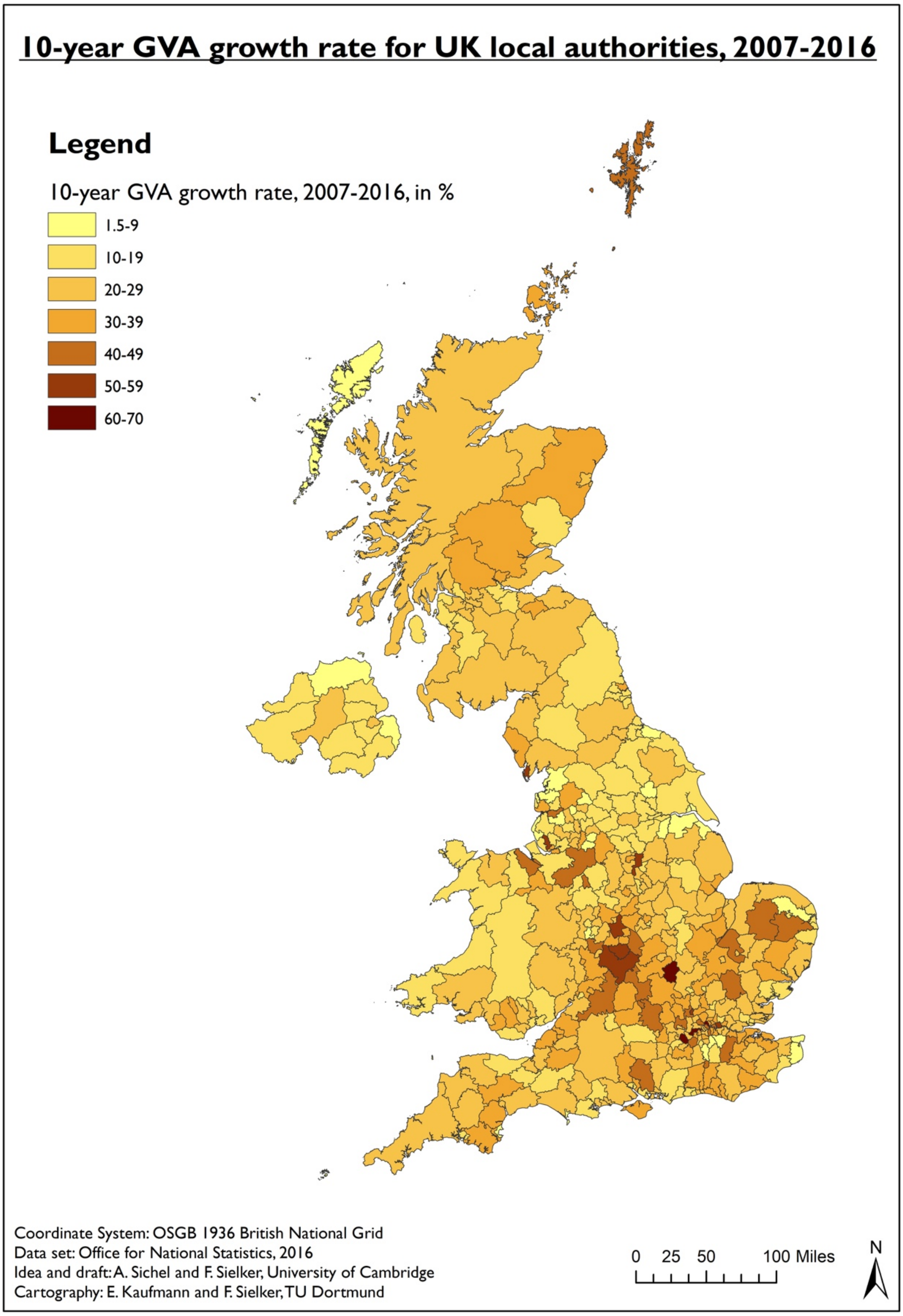


While analysing the composite Growth Potential Index may give a general indication as to the growth trajectories of local authorities, it can mask variability. Therefore, below, we explore the spatial distribution and dynamics present in each indicator that comprises the Growth Potential Index.

GVA 10-year growth rate

The average 10-year GVA growth rate in the UK is 25%. Our analysis of the spatial distribution of 10-year GVA growth rates, when compared to the balanced GVA per head growth rate the, shows that few areas perform exceptionally well over the 10 year period, though performance was stronger in urban areas, such as some London boroughs, Oxford, Birmingham, Sheffield and Liverpool (Figure 18). In general, and as expected, more rural areas show weaker performance over the decade. In terms of digitalisation processes, it is expected that this long-term performance will have an impact on the capacity of local authorities to contribute to digitalisation; however, our study shows that ability to digitalise does not map perfectly to where economic growth exists, as Scotland has made strong strides towards digitalisation.

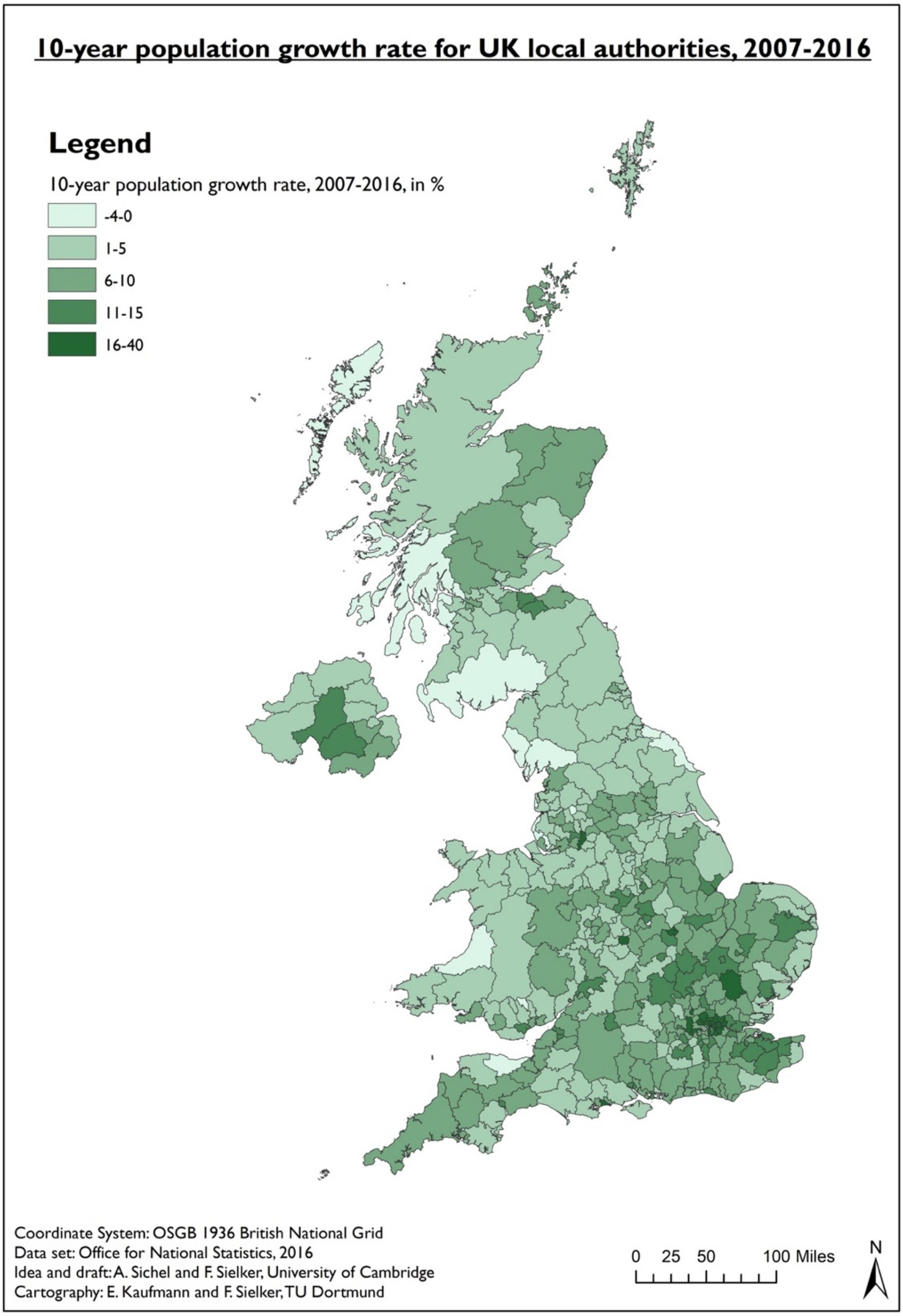
Figure 18



Population 10-year growth rate

The average 10-year population growth rate in the UK is 6%. As Figure 19 shows, the parts of the UK with the highest 10-year population growth rates, ranging between 16 and 40%, are to be found around London, and in other urban centres. Notably, though most of the UK shows at least slow growth, there are several areas that have illustrated shrinkage over the past 10 years, including Cardingshire in Wales, and parts of Yorkshire.

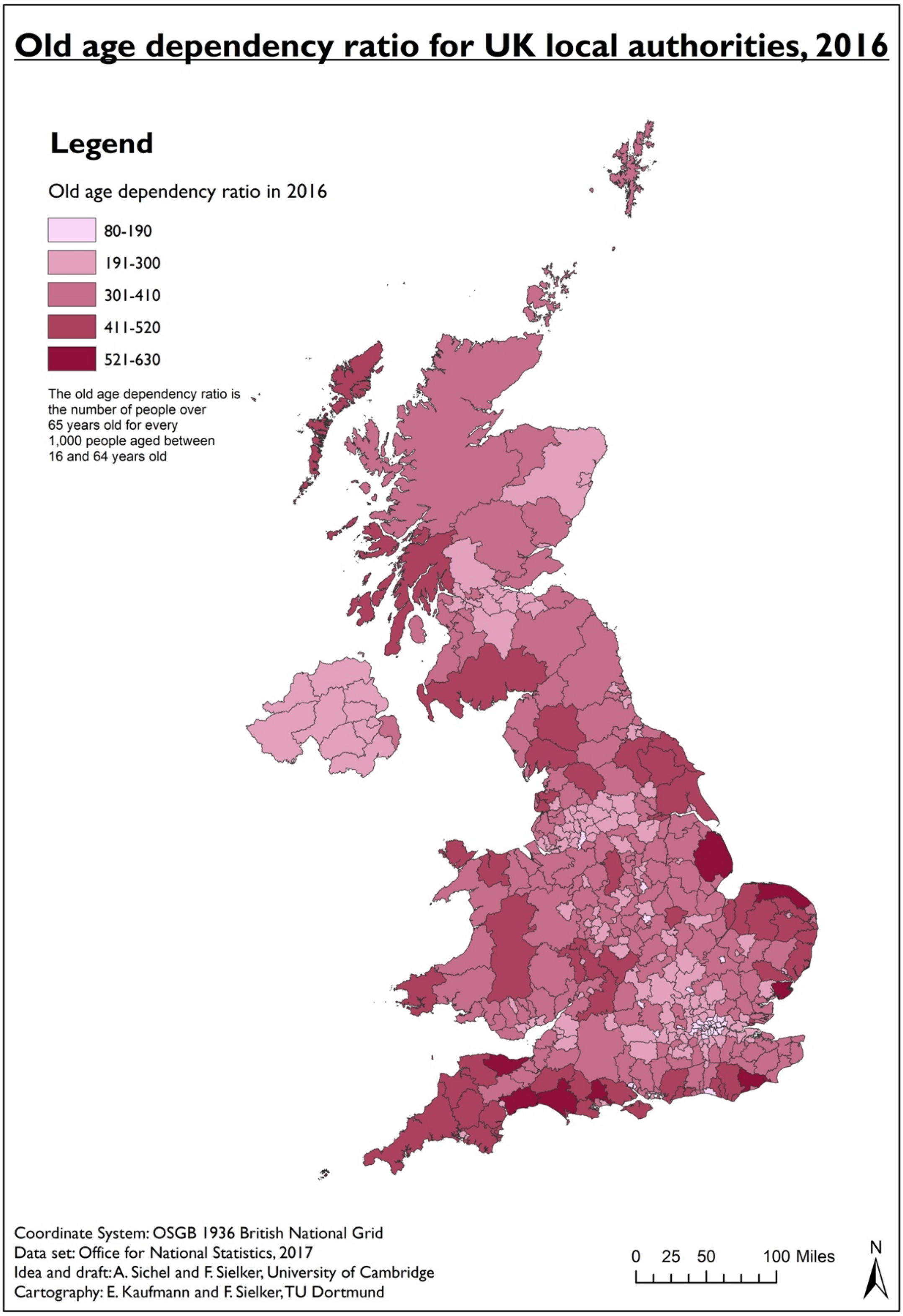
Figure 19



Old Age Dependency Ratio

The Average Old Age Dependency Ratio in the UK is 318. Note that for Old Age Dependency Ratio, a lower number will generally indicate a stronger growth potential, as it means that there are more people of working age, as compared to those above working age. Examining the spatial distribution of old age dependency shows that it mirrors the urban-rural divide in the UK. Overall, highest ratios can be found in local authorities on the coasts, and younger populations in urban areas, and in the UK's university cities (Figure 20).

Figure 20

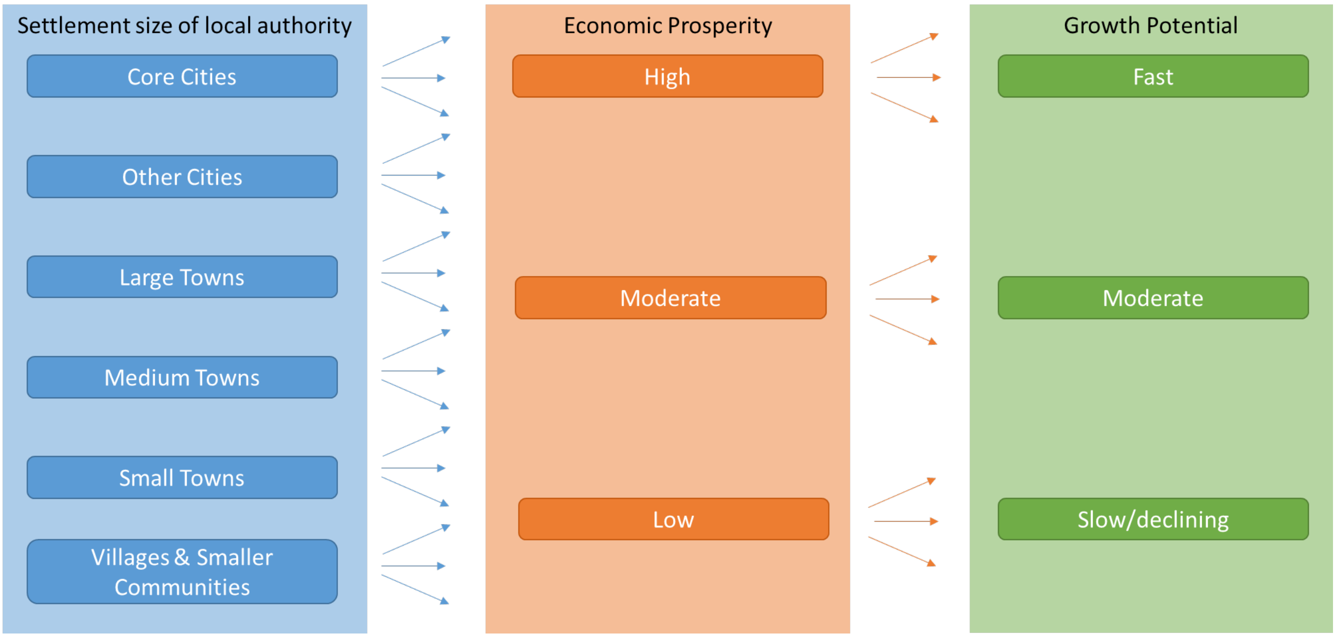


4.1.4. Local authority typology

To create a typology to categorise local authorities by their economic strength, settlement type, and growth potential, we put together the indicators analysed above into a matrix, to create 54 different local authority types (Figure 21). In keeping with the analysis above, the majority of Core Cities displayed Fast Growth and High or Moderate prosperity. The other categories, however, saw much more variability.

Figure 21

Local Authority Typology – 54 potential local authority types



Source: own elaboration

4.2. Case study selection and analysis

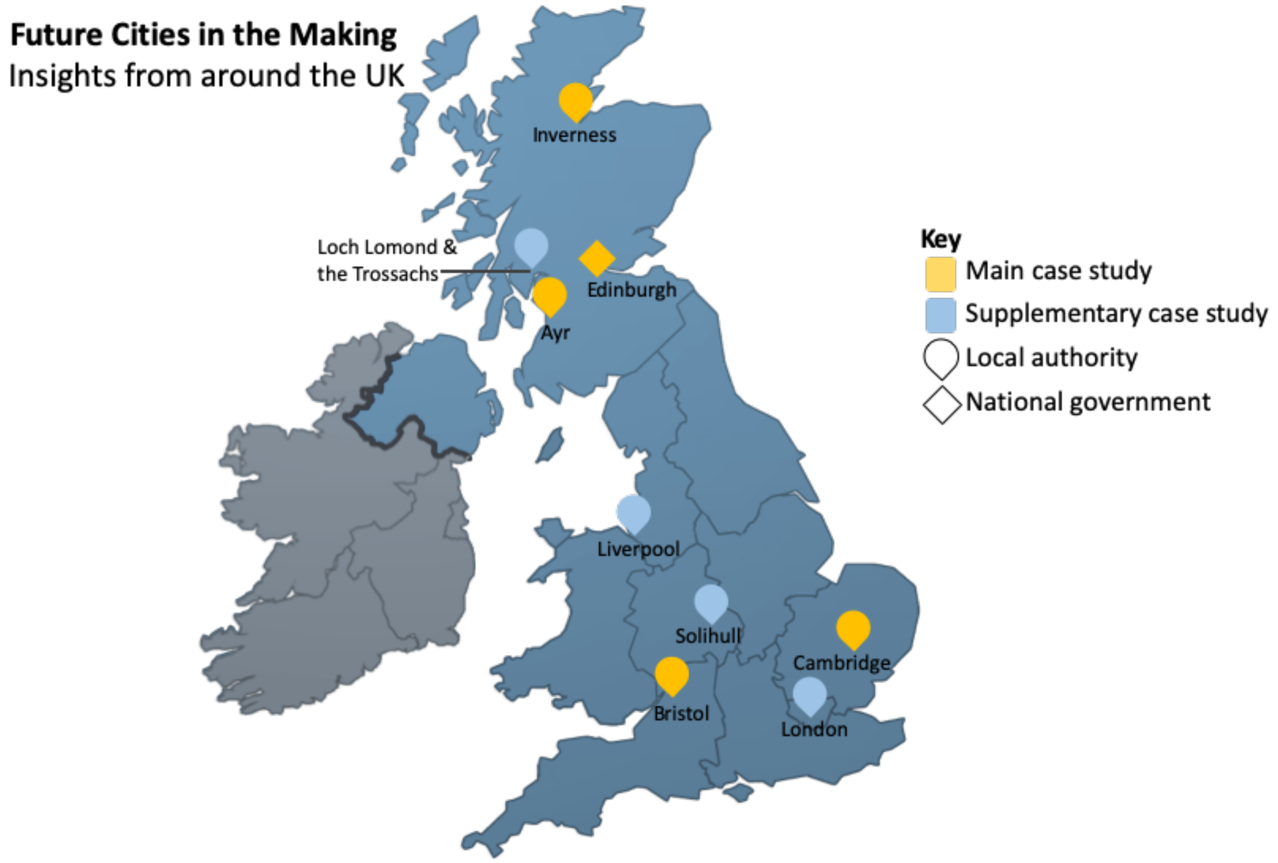
Based on insights drawn from the local authority typology analysis, as well as an analysis of the types of government present in each area, and a willingness to engage with the research project, two local authority case studies and one national case study were selected:

- Bristol, to represent the Core Cities with High economic prosperity and Fast growth and unitary authorities
- Cambridge, to represent a Large Town[1] with High economic prosperity and Fast growth
- Scotland, to analyse multi-level governance structures, and a different planning system. In Scotland, we also deeply engaged with:
  - South Ayrshire, a Medium Town, with Moderate economic prosperity and Slow/declining growth
  - Highland, a Village or Smaller, with Moderate economic prosperity and Moderate growth

[1] Cambridge is legally classified as a city; however, in the House of Commons classification system, it looks at size and density of settlements, not official legal status. Therefore, for the purposes of this study, Cambridge is considered a Large Town.

The figure below illustrates the geographic areas and stakeholders with which this research engaged (Figure 22). The sections below investigate the dynamics present in each case study, and illustrate some findings.

Figure 22



Source: own elaboration

4.2.1. Bristol

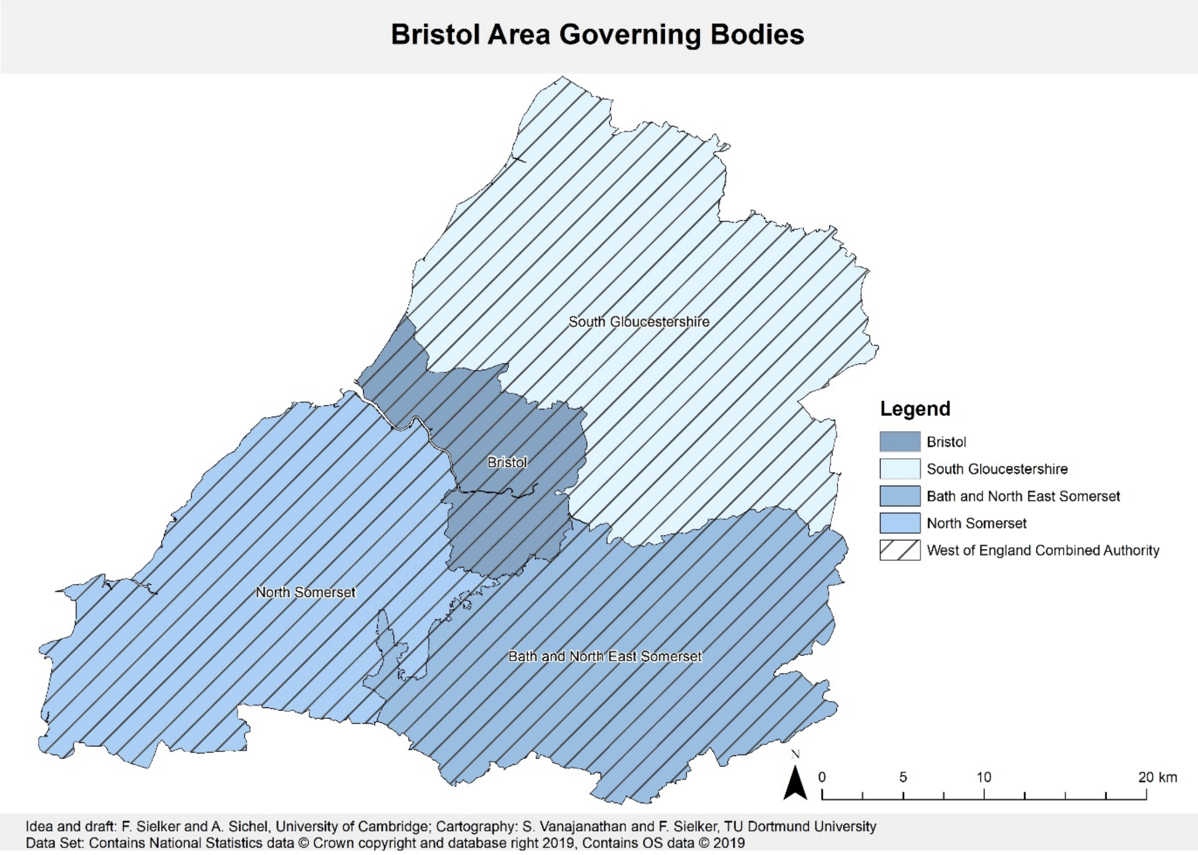
4.2.1.1. Case study selection and context

Governance and planning structure

Bristol is in England, and so is subject to the English planning system. It is a unitary authority, which means that its responsibilities and functions are not divided between district and county level governments, but all housed within one authority. A directly elected mayor controls the authority's executive function, which is relatively uncommon in the UK. The Labour Party secured an overall majority in the council in the 2016 elections, and the current mayor, Martin Rees, is also from the Labour Party. As will be demonstrated throughout the remainder of this report, the unitary structure of the council and the political accord between branches of government are important factors in overcoming barriers to digitalisation and implementing information modelling for planning. Bristol has fewer barriers to overcome because its governance structure and political landscape support collaborative, joined-up action. This is perhaps one reason that the city has been successful in pursuing smart city aims, which is discussed further in the section below.

Bristol recently became part of a larger governing entity, the West of England Combined Authority (WECA). WECA is comprised of Bath & North East Somerset, Bristol and South Gloucestershire (Figure 23). WECA has been given powers over spending, previously held by central government, on the region's transport, housing, adult education, and skills. The four West of England councils are working to produce a West of England Joint Spatial Plan, which will set out a plan for sustainable growth to help the region meet housing and transport needs to 2036. At the time of the writing of this report, this strategic document was under review. Because WECA was founded recently (2017), it has not yet had a large impact on how Bristol plans and operates. However, as the competencies WECA assumes were previously held by central government and not by local authorities, it is likely that the addition of this second tier of governmental hierarchy will not add to governmental fragmentation at lower levels, which our analysis shows to be a major barrier to implementing information modelling for planning, discussed further below. Stakeholders hope that instead it will add a more strategic level of coordination between regional partners.

Figure 23



Socioeconomic context

Bristol was chosen to represent a large metropolitan area with strong growth potential (Table 11). It was also selected because the area is undergoing a large amount of regeneration, and the analyses aimed to understand how information modelling needs in areas focused on regeneration might differ from needs in areas focused on new build. Desk analysis reveals that although the authority's GVA per head is below the national average, the city struggles with stark inequality (Bristol City Council, 2018a), with pockets of the city flourishing economically, and parts struggling with poverty.

Table 11: Bristol demographic indicators

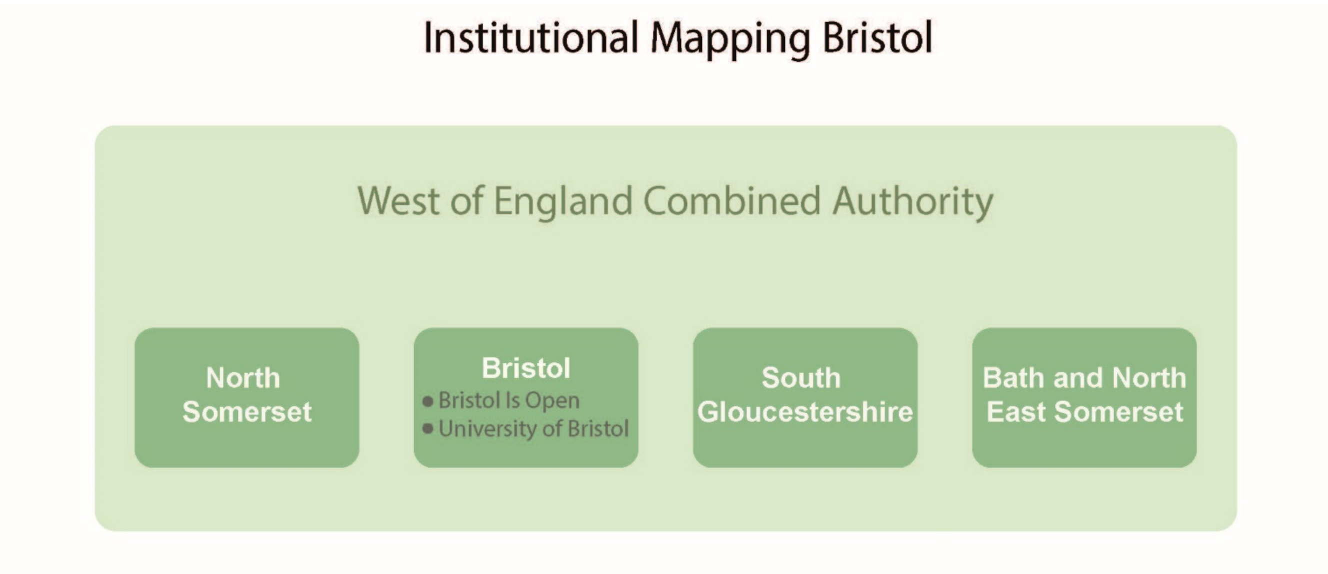
Indicator	Value	Ranking
GVA per head	£31,513	Below average
Representative settlement type	Core City	(N/A)
Growth potential index score	90	Fast
10 year GVA growth rate	32%	Above average
10 year population growth rate	10%	Above average

Old age dependency ratio	192	Below average

Engagement with smart city concepts

Bristol is consistently recognised as one of Britain's smartest cities (Woods et al., 2017). It boasts a strong innovation sector, and has multiple municipal stakeholders committed to transforming the city into a world-leading smart city that prioritises residents over technology. Within the local authority, there is a team dedicated to developing Bristol's smart city strategy. Outside of the council, Bristol is home to Bristol is Open, a joint venture between the University of Bristol and Bristol City Council. Bristol is Open is dedicated to developing and delivering initiatives and research that contributes to the development of a smart city, and has been active across multiple fronts in delivering the infrastructure and ideas necessary to continue promoting Bristol. An institutional map of the major stakeholders who were considered and engaged for the purposes of this analysis is included below (Figure 24).

Figure 24



Source: idea and draft own elaboration, created by S. Vanajanathan

4.2.1.2. Bristol case study analysis

Bristol has been recognised internationally as a leading smart city, and has a number of initiatives that promote digitalisation and that may support the roll out of information modelling in the planning context. It is internationally recognised as one of the smartest cities in the UK (see, e.g.: Woods et al., 2017). We analysed factors that have facilitated digitalisation in Bristol, and also potential pitfalls for the area as it progresses towards greater levels of digitalisation.

Enablers of digitalisation and information modelling for planning in Bristol

Not only is Bristol recognised in smart city rankings as being a leader in the UK, our stakeholder interviewed that Bristol remains on the cutting edge of city innovation in the UK. In our case study analysis, we identify three factors that significantly contribute to Bristol's ability to overcome barriers to digitalisation: governmental structure, organisational arrangements, and leadership. These same factors will also enable the city to better approach barriers to implementing information modelling for planning.

Governmental structure

As the barriers analysis below explores further, governmental fragmentation can pose a serious barrier to digitalisation in general, and will be a hindrance to implementing information modelling for planning.

As a unitary authority, Bristol's governance structure is fairly unified. Furthermore, there is no political difference between the executive branch of the city, and the city's council, which helps align priorities and budget. Although stakeholders did note the existence of data silos in Bristol, this appeared to be much less of a challenge in Bristol than in, for example, Cambridge. This is likely attributable, at least in part, to the much more cohesive and less complex nature of Bristol's governmental structure.

The city recently engaged in a collaborative city strategy creation exercise that involved regularly convening leaders from across the public, private and third sectors. This has also helped strategic collaboration in the city.

Organisational arrangements

Beyond the governmental structure, features of Bristol's organisational arrangements are conducive to collaboration, which, as this report argues below, is an enabler of digitalisation and a requisite ingredient for facilitating information modelling for planning. Bristol has several notable organisational features that are supportive to digitalisation. Firstly, Bristol has a corporate team that serves multiple parts of the council, and is responsible for maintaining the council's GIS data and systems. Having a team that is dedicated to IT and data management helps ensure that the rest of the organisation works with uniform and standardised data, and has the technical support necessary to fulfil job functions.

Recognising the power of collaboration and joined-up ways of working, Bristol co-located several data-driven service into one centralised operations centre, which has led to unanticipated benefits to residents. This is covered more in section 4.6, which is on overcoming barriers. Another example of Bristol's joined-up way of working can be seen through the city's 'one dig' policy. When the city digs up the road to install, for example, a new heat network, it also puts in new fibre for broadband connections. This is a powerful example of how coordination between departments can enable savings across the board. While this example relates to physical infrastructure and assets, it is also relevant to digital infrastructure and assets.

Furthermore, Bristol supports the further development of their planners by providing them with time to pursue additional projects and training. One planner was actively engaged with understanding how BIM can be used in city modelling, and was working to figure out his own code. Planners in Bristol appeared empowered and referenced innovative initiatives involving planners as being driven from the bottom up. For instance, planners indicated that Know Your Place, an inventive project implemented to enable residents to explore their neighbourhood's history through historical maps and data, was brought into existence by bottom-up interest.

Below, we argue that organisational arrangements that support both collaboration as well as the development of individuals helps to overcome barriers to digitalisation and implementation of information modelling for planning, the Bristol case study illustrates the effectiveness of these measures.

Leadership

Our analysis below highlights the importance of leadership in enabling digitalisation for planning and local authorities. The Bristol case study is a good example, showing how leadership that prioritises digitalisation can enable it across the organisation. There are specific leadership roles in the city focused on digital innovation, ranging from a dedicated smart city manager, to a strong leader of the area's smart city and innovation JV, Bristol is Open. These leaders were engaged with city strategy on multiple levels. As is argued below, leadership is key to enabling digitalisation and will be crucial to facilitating implementation of information modelling for planning.

Privacy and data ethics concerns

Many aspiring smart cities, Bristol included, are looking for new ways to use data to improve efficiency and to better serve citizens. However, for local authorities this push towards data-driven service provision must co-evolve with socially responsible ways of managing data collection and use. As is covered in more detail in the legal barriers section (4.5.6) below, as Bristol considers designing and using smart homes, it must be sure to collect truly informed consent from participants. Otherwise, smart homes risk violating their inhabitants' right to privacy, broadcasting what is done privately in the home to the government, and any attendant third parties.

4.2.2. Cambridge

4.2.2.1. Case study selection and context

Governance and planning structure

Cambridge is in England, and so is subject to the English planning system. Cambridge has a complex governance structure, with many different governmental actors responsible for delivering the area's growth agenda. The relevant actors include the Cambridgeshire and Peterborough Combined Authority, Cambridgeshire County Council, Peterborough City Council, South Cambridgeshire District Council, East Cambridgeshire District Council, Huntingdonshire District Council, and Fenland District Council, and the Greater Cambridge Partnership (Figure 25 and Figure 26)

Cambridgeshire and Peterborough Combined Authority was created in 2017, and is led by a mayor. The combined authority is made up of Cambridgeshire County Council, Peterborough City Council, Cambridge City Council, South Cambridgeshire District Council, East Cambridgeshire District Council, Huntingdonshire District Council, and Fenland District Council. The combined authority is responsible for a budget for local growth, housing, transport, skills training and apprenticeships, integration of local health and social care resources, and integration of local employment services. The combined authority is overseen by a directly elected mayor, James Palmer, who is a Conservative.

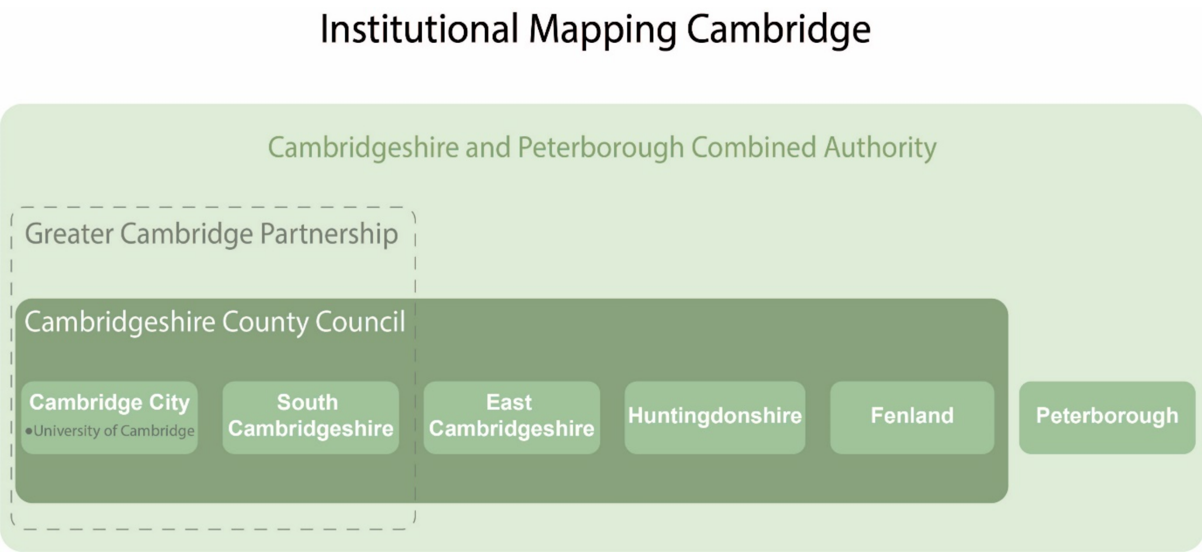
Peterborough is a unitary authority, which means that its governmental competencies are not divided between county and district level governments, but held within one governmental body.

The Cambridgeshire County Council is responsible for county-level administration for the Cambridgeshire area (excluding Peterborough). This includes providing education, social care, waste disposal, strategic planning, and transport planning. However, functionally, the county council has handed some of these responsibilities, particularly transport planning, over to the Greater Cambridge Partnership, which is covered in more detail below. The Cambridgeshire County Council is controlled by the Conservative Party.

Sitting below the county council in the administrative hierarchy are the district-level councils of the area, which include Cambridge City Council, South Cambridgeshire District Council, East Cambridgeshire District Council, Huntingdonshire District Council, and Fenland District Council. Each district council is responsible for planning for its own local authority area, with the exception of Cambridge City Council and South Cambridgeshire, which recently entered into a joint planning service arrangement. Cambridge City Council is controlled by the Labour Party, while South Cambridgeshire District Council is controlled by the Liberal Democrats.

The Greater Cambridge Partnership is the delivery body for the City Deal with central Government, which was signed in 2014. The Greater Cambridge Partnership includes Cambridgeshire County Council, Cambridge City Council, South Cambridgeshire District Council and the University of Cambridge. The partnership is worth up to £500 million in funding for transport infrastructure to boost economic growth, and has additional goals to contribute to housing production, job creation, and air quality improvements, among other things. Progress on the GCP's goals has been hindered, however, by clashes between partnership stakeholders (Thomas, 2018).

Figure 25



Source: idea and draft own elaboration, created by S. Vanajanathan

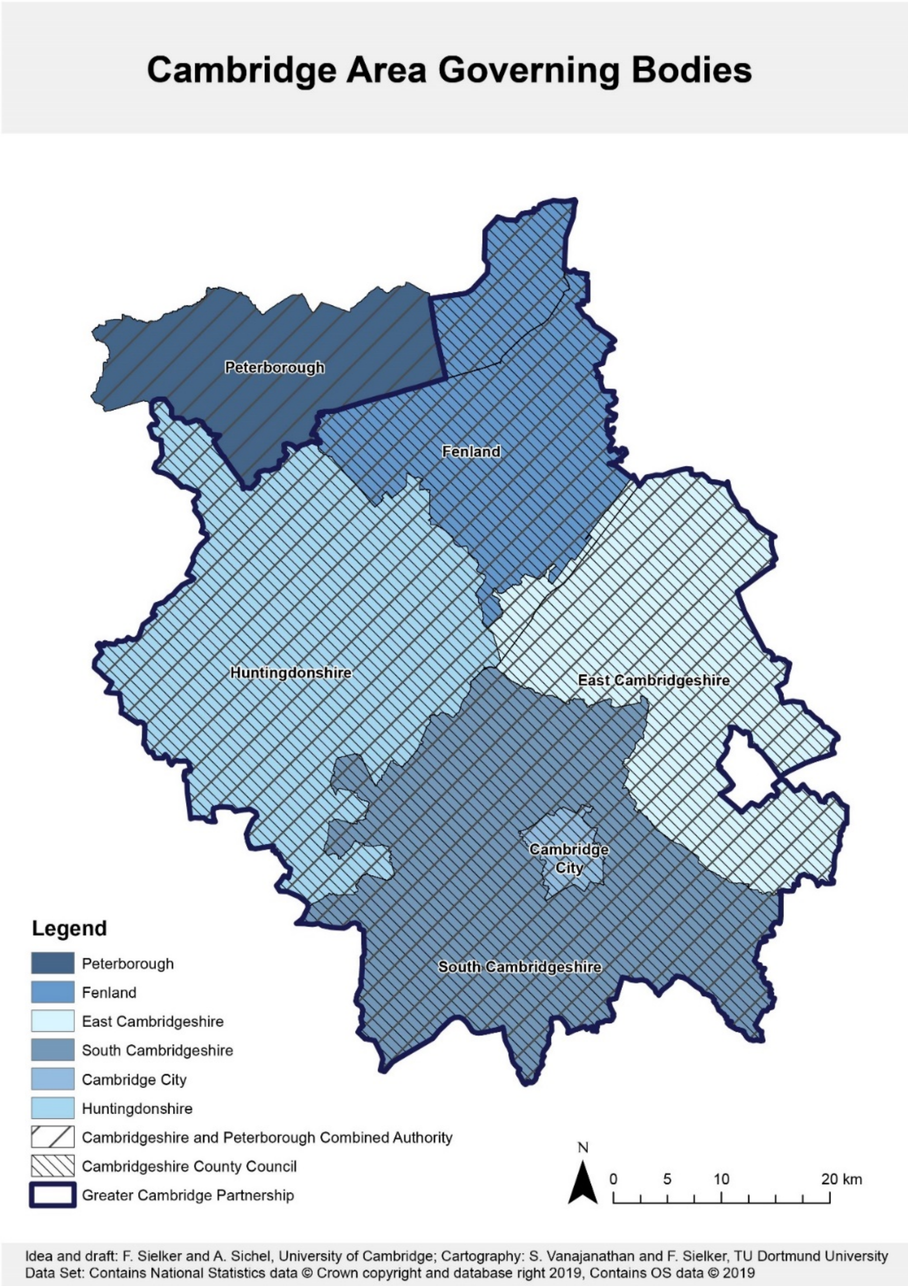
Socioeconomic context

Cambridge was selected as a case study to represent a local authority with smaller settlement sizes, contending with rapid growth. As the indicators detailed in Table 12 illustrate, Cambridge's economy is above average, with GVA per head above the national average, and strong economic growth over the past ten years. Cambridge is the only case study in our analysis with GVA per head that is above the national average. Cambridge is not a major metropolitan area like Bristol, so it represents a point of contrast. Similar to Bristol, however, Cambridge shows very strong growth potential, with GVA and population growth rates well above the UK average, and a lower than average Old Age Dependency Ratio. Due to this growth, Cambridge, like Bristol, is struggling to expand its housing and transport capacities, to help facilitate continued economic growth. Unlike Bristol, however, Cambridge is focused more on new development, whereas Bristol is focusing on regeneration. This offers another interesting point of comparison between the two.

Table 12: Cambridge demographic indicators

Indicator	Value	Ranking
GVA per head	£38,900	Above average
Representative settlement type	Large Town	(N/A)
Growth potential index score	90	Strong
10 year GVA growth rate	29%	Above average
10 year population growth rate	10%	Above average
Old age dependency ratio	166	Below average

Figure 26



Engagement with smart city concepts

Through the Greater Cambridge Partnership, the Cambridge area is engaging with smart city concepts. Specifically, Smart Cambridge, which falls under the umbrella of the Greater Cambridgeshire Partnership, and also Cambridgeshire County Council's Connecting Cambridgeshire programme, is exploring how data, innovative technology and better connectivity can be used to transform the way people live, work and travel in the area and beyond. Smart Cambridge is focused on making the greater Cambridge area a smart city region, by providing the infrastructure necessary to collect and analyse data that can be used to develop solutions to the area's challenges surrounding its rapid growth.

4.2.2.2. Cambridge case study analysis

The Cambridge area has strong momentum towards more sustainable transport systems, and is experimenting with digital twin concepts. Much of its momentum is driven by the city's fast growth. This, in some ways, places the Cambridge area at the cutting edge of digitalisation and smart city exploration in the UK. However, our case study revealed that the governance structures in the area hinder digitalisation and this will likely present a challenge to any efforts towards deploying information modelling in planning.

Pressure of fast growth

As the analysis above shows, Cambridge is experiencing incredibly strong growth. Stakeholders shared that unless the infrastructure of the areas is built out, constraints imposed by congestion and housing shortages will block further economic growth in the area. In this context, Cambridge stakeholders are dedicated to using all tools at their disposal, including further digitalisation, to address potential bottlenecks to further economic growth. Smart Cambridge has been actively engaged in trying to facilitate better transportation experiences through digital engagement with real-time bus monitoring, sensors, cameras, and the Greater Cambridge Partnership has developed plans to expand transportation in the area. However, the governance structure Cambridge is fragmented, which makes it difficult to align priorities and funding to support digital initiatives.

Complex governance structure

As Figure 25 above illustrates, the governance structure in Cambridge is complicated. Different bodies have overlapping jurisdictions. For example, there are at least six local plans in the Cambridgeshire and Peterborough Combined Authority area, although Cambridge City Council and South Cambridgeshire District Council are hoping to sync their plans as they are now part of a combined planning service. Overlapping competencies and different strategic priorities makes it difficult for alignment and coordination, which is important for meaningful digitalisation efforts. This governmental fragmentation has implications for how organisations are able to share data with one another, and may present challenges to finding standard ways of using and recording data.

The complex governance structure in Cambridge also makes it uniquely more vulnerable to political conflict. For example, the Greater Cambridge Partnership is comprised of the Cambridgeshire County Council, which is currently controlled by conservatives, the Cambridge City Council, which is controlled by the Labour Party, and South Cambridgeshire District Council is controlled by yet a different political party, the Liberal Democrats. However, these parties are jointly responsible for setting a transportation vision for the area. Added to this, the mayor of the Combined Authority must be in agreement with the Greater Cambridgeshire Partnership's strategies. The number of active governmental organisations and delivery bodies in the Cambridge area, combined with their political disunity, presents a barrier to effective priority-setting, procurement coordination and strategic planning for information modelling.

4.2.3. Scotland

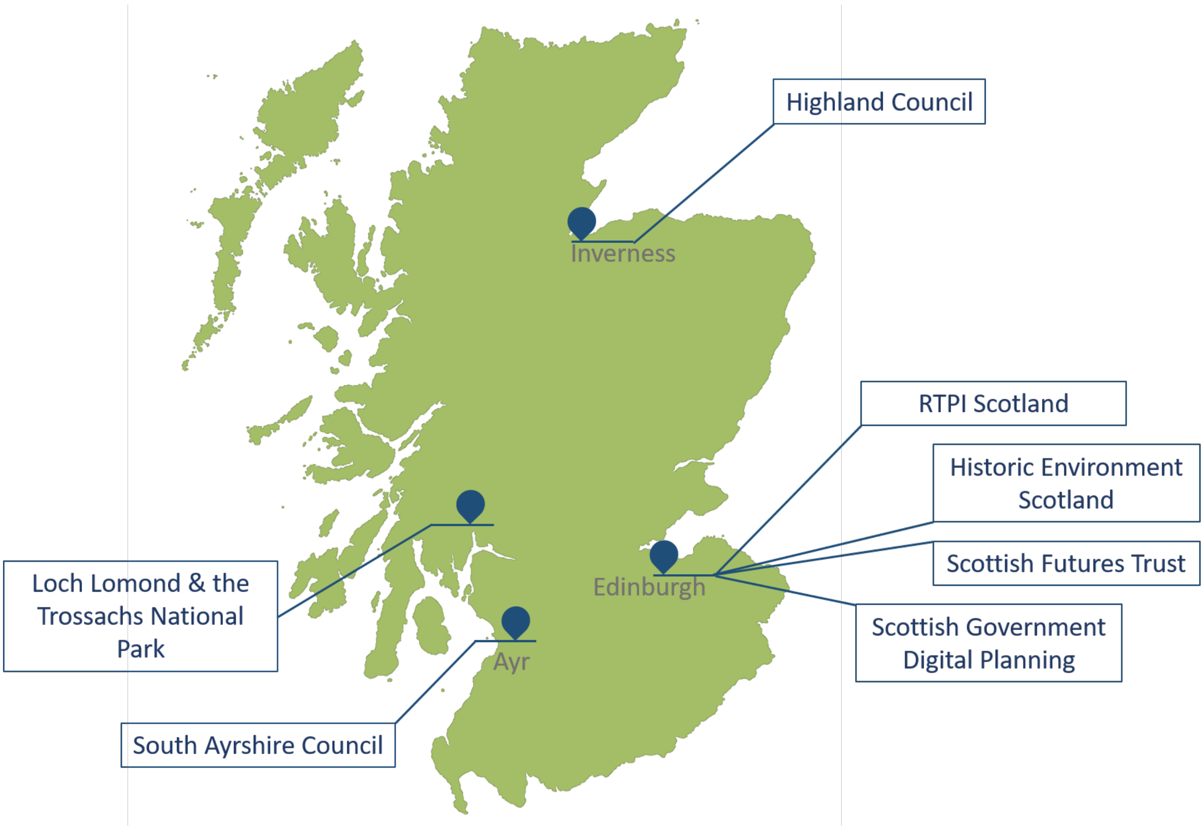
4.2.3.1. Case study selection and context

Governance and planning structure

While the other two case study areas were focused on jurisdictions covered by local authorities, our third case study is unique in that it looks at planning at the national and local levels. We selected Scotland, as its planning system is distinct from the English system (the differences are covered in more detail in section 2.1 on UK planning systems). Of particular note for this part of our analysis, the Scottish Government is involved in the planning system, and has historically been active in partnering with local authorities around digitalisation initiatives. Focusing on planning initiatives at the national level in Scotland provided a window into the strategic level of coordination involved in planning in the area, initiatives related to digitalisation in planning, and thinking around BIM roll-out on a national scale. In Scotland, we engaged with a number of national bodies, including: the Scottish Government's digital planning team; Scottish Futures Trust, which is actively involved in supporting the roll out of BIM across governmental departments; Historic Environment Scotland, which is incorporating BIM into their property management systems; and the national planning membership body, the Royal Town Planning Institute Scotland. To study planning at a local level, we selected two local authority areas, Highland

and South Ayrshire, to see how planning in Scotland played out at a local level and to investigate the planning challenges different local authorities faced. We also engaged with Loch Lomond and the Trossachs National Park for additional insight on planning processes across Scotland. For the geographic distribution of our case study stakeholders, see Figure 27 below.

Figure 27: Map of Scottish case study stakeholders



Source: own elaboration

Socioeconomic context and selection of Scottish local authority focus areas

Two local authorities were selected as focus areas for the Scottish case study, Highland and South Ayrshire. Highland was selected for several reasons. Highland's local economy is smaller than the national average, with a GVA per head of £23,307, about 40% below the national average of £37,907. It was also selected because it represented more rural settlements, which were not represented in the other case studies. The majority of Highland residents living in settlements that are village sized or smaller. Geographically, Highland is the largest local authority in the UK and at 25,657 square kilometres, it represents over 11% of the UK, but is sparsely populated. This made Highland a particularly interesting case study, as the authority has had to contend with managing an area that is geographically very dispersed. This has pushed them to consider more digital ways of working. Highland has a number of digitalisation initiatives to facilitate more efficient work practices, given their challenging geography. While they do not use the smart city moniker, they have been pushing forward with several digitalisation initiatives, which supported our selection criteria. The area's growth index is below average, with population growth and old age dependency pointing towards growth below the UK average. The area's economy, however, is growing at a rate slightly above the UK average (Table 13).

Table 13: Selected Scottish local authority demographic indicators

Indicator	Value	Ranking
Highland		
GVA per head	£23,307	Below average
Representative settlement type	Village or smaller	(N/A)
Growth potential index score	50	Below average
10 year GVA growth rate	27%	Above average
10 year population growth rate	5%	Below average
Old age dependency ratio	346	Above average
South Ayrshire		
GVA per head	£23,375	Below average
Representative settlement type	Medium Town	(N/A)
Growth potential index score	33	Below average
10 year GVA growth rate	30%	Above average
10 year population growth rate	0%	Below average
Old age dependency ratio	404	Above average

South Ayrshire was selected as a second local authority focus for the Scottish case study for several reasons. It represents a settlement size not covered in any of the other case studies (Medium Town). South Ayrshire's socioeconomic indicators also made it a relevant case study: although its GVA has been growing, its population size has essentially been stagnant, and it has the highest Old Age Dependency Ratio out of all case study areas. The local authority was happy to engage with the research, but does not have a specific digital agenda or digitalisation plans, as our other case study cities did. In this sense, South Ayrshire was a control study, providing a window into the barriers to information modelling that more rural authorities that are not focused on digitalisation might face. If information modelling becomes central to planning, it will be relevant not just to cities but also to rural areas, and so engaging with communities that do not frequently feature in smart city debates was important to this research design.

4.2.3.2. Scotland case study analysis

Several factors combine to make this a dynamic time for planning and digitalisation in Scotland. In 2016, a review of the planning system highlighted opportunities for digitalisation to help improve planning and as a result, a Digital Task Force was formed with the aim of giving Scotland a first-rate planning system, enabled by digitalisation. At the same time, the 2017 Scottish BIM mandate brought focus to using digital tools for infrastructure management across the Scottish Government, which is in the process of redesigning the planning system through a new planning bill. Our time in Scotland highlighted that the Digital Task Force is not, as of yet, considering how BIM can support their digital planning service, but that other areas of government, such as Scottish Futures Trust and Historic Environment Scotland, are more active in this area. This case study also illustrated a model of collaboration between different levels of government, and highlighted the role that digitalisation in planning can play in drawing out more strategic planning gain through increased collaboration.

Scottish Government and digitalisation in planning

The Scottish Government is focused on creating a world-leading digital planning service. At present, they have several initiatives in this area, creating prototypes that visualise planning data in different ways to reveal investment patterns and development trends, for example. They are also working on improving the customer interface and the public engagement process, prototyping a planning system platform that would enable the public to see proposed developments in 3D, track progress on applications, and follow changes to different local areas. The user interface is designed to be easy-to-navigate and encourage engagement. The Scottish Government is in dialogue with Scottish Futures Trust to envision potential future uses of BIM in the Scottish planning system, and has prototyped the use of BIM within the planning application process, but found that, given current technology constraints, deployment across the planning system is not yet feasible.

It is clear that Scottish Government engages regularly with its 32 local authorities, as they have various different working groups that enlist participation from the local authorities. However, local authorities expressed concern surrounding the next iteration of Scotland's digital planning service. Reportedly, when Scotland adopted ePlanning, it did not immediately integrate Building Standards into this process, which negatively affected authorities that have strong collaborations between planning and Building Standards departments. eBuilding Standards, as Scotland's online Building Standards portal is called, has been live for three years, so integration issues between eBuilding and ePlanning are at this point historical. However, this example does point to the challenges of rolling out major capital investment projects. Major projects require funding, and securing funding requires time and a robust business case, ideally based on an extant successful model. In the case of eBuilding Standards, money was secured based on earlier successes of ePlanning. As digitalisation initiatives move forward, it will be necessary to strike a balance between moving all systems forward together, and iteratively and incrementally implementing digital initiatives to make sure to get them right. This is true across all sectors, but particularly in the case of the public sector, where public funds are allocated to major capital projects. This balance is crucial to making sure that public funds are used responsibly, and to ensure that technological interventions facilitate greater collaboration in the planning system, a key priority discussed later in this report.

Revitalisation of planning in Scotland

One theme that replayed across nearly all of our interviews in Scotland was the importance of rejuvenating the role of planning. Planning can play a strategic role, spatially aligning resources with needs for the present and future. Planning can also be a facilitator, convening different parts of government, responsible for delivering services such as education and roads, to collaboratively create a vision and a capital resource plan to support the future. Digital tools can support these strategic purposes, giving planners better data to use when making professional judgements, and making public engagement easier and more meaningful. However, planning must be seen as more than a tick box exercise, and communication between departments and across levels of government is of paramount importance. This is an area in which information modelling and strong sharing systems could be effective in enhancing the benefits delivered through the planning system. Platforms and systems that create space for data sharing and communal planning will help ensure that planners make decision based on good information, which will lead to more useful plans. Further, as information modelling for planning evolves, information modelling can support scenario building, which can support planners in making better decisions about development. The role that technology can play in facilitating better planning in this context is worth pursuing.

Building a business case

Engagements with local authorities in Scotland highlighted the need for a strong business case to be made before new technology is adopted. Current technological solutions are enabling more digital ways of working, but there is significant concern around where data is stored and how much data storage costs, as is covered in more detail in the barriers section below. Local authorities need to have a clear business case in mind to get funding for digital interventions. This makes Scottish Futures Trust's engagement around business cases intriguing. They have built out a website that enables users to analyse their own business case for utilising BIM. Creating such a tool for adopting information modelling in planning will be helpful to eventually catalyse its broader roll-out.

Geography as a driver

As expected, local context plays an important role in determining how local authorities engage with digitalisation. For example, because Highland has the duty to cover such a large territory it has become a leader in adopting digital, mobile ways of working. Highland reported previously moving physical files between offices by car in boxes. However, following a digitalisation effort, the council moved to allocating work and sharing files electronically. Now applications are handled based on the capacity of staff across the Highland HQ and field offices, not based on where the application was made. This enables a more efficient use of human resource. Additionally, Highland has been pursuing opportunities for more mobile ways of working, to save the time and money required for planners to shuttle back and forth between sites and back offices. Highland's process is a good example of digitalisation, because when they adopted new digital tools, they also embarked on a change process that fundamentally altered the way they operated and shared work across their field offices, as opposed to just making digital what was once done in analogue.

4.3. Baseline: Stakeholder awareness of BIM, CIM, and digital twins

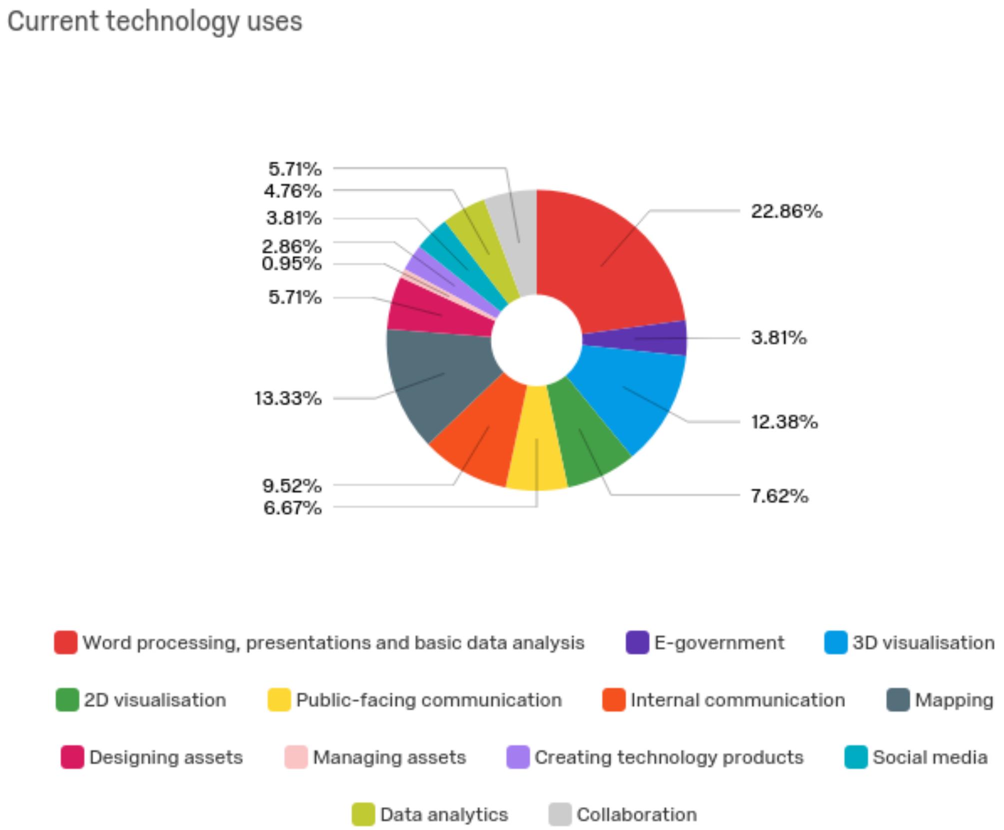
4.3.1. BIM uses in the planning context

To understand how information modelling is used and perceived by planning stakeholders, we dedicated part of our questionnaire to addressing these questions. Our research confirmed previous studies (e.g. Allmendinger and Sielker, 2018; Sielker and Allmendinger, 2018) that show that BIM does not feature in most UK planning processes. There is growing interest from local authorities in BIM as an asset management tool, and there is a move on the part of software developers and the aviation sector to link BIM and geospatial data. There are some efforts to use BIM for facilities management, and there are isolated instances of BIM use for submitting application for building control. However, BIM, as of yet, does not feature much in the planning process.

Current technology engagement

To understand current practices, this research explored the types of tasks for which stakeholders currently use technology and software. Findings revealed that a comparatively large portion of respondents use 3D visualisations in their daily work, second only to the number of respondents who said they use technology and software for standard tasks like word processing, presentations and basic data analysis. After 3D visualisation, the next most common use for technology and software was mapping. Taken together, these three functions account for nearly 50 percent of the functions for which respondents use technology and software (Figure 28).

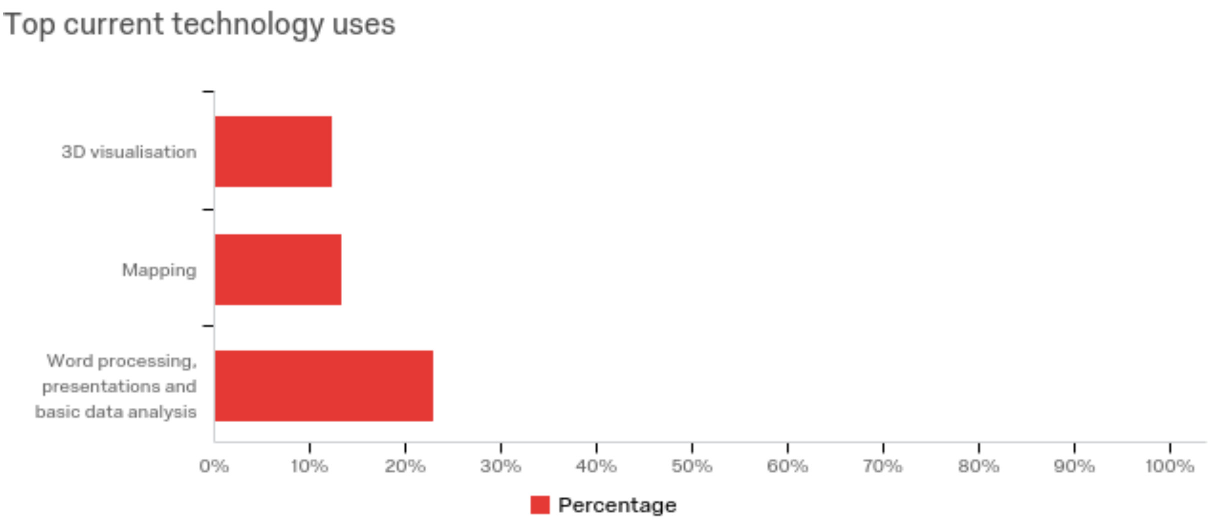
Figure 28



Source: own elaboration

Looking at the breakdown of what stakeholders perform which types of tasks with technology and software, the use of 3D visualisation remains consistently high across stakeholders from local government, national government and developers. Taken together, this indicates that stakeholder groups active in the planning system are already comfortable using 3D visualisation technologies and geospatial mapping, which may support BIM and CIM adoption (Figure 29).

Figure 29



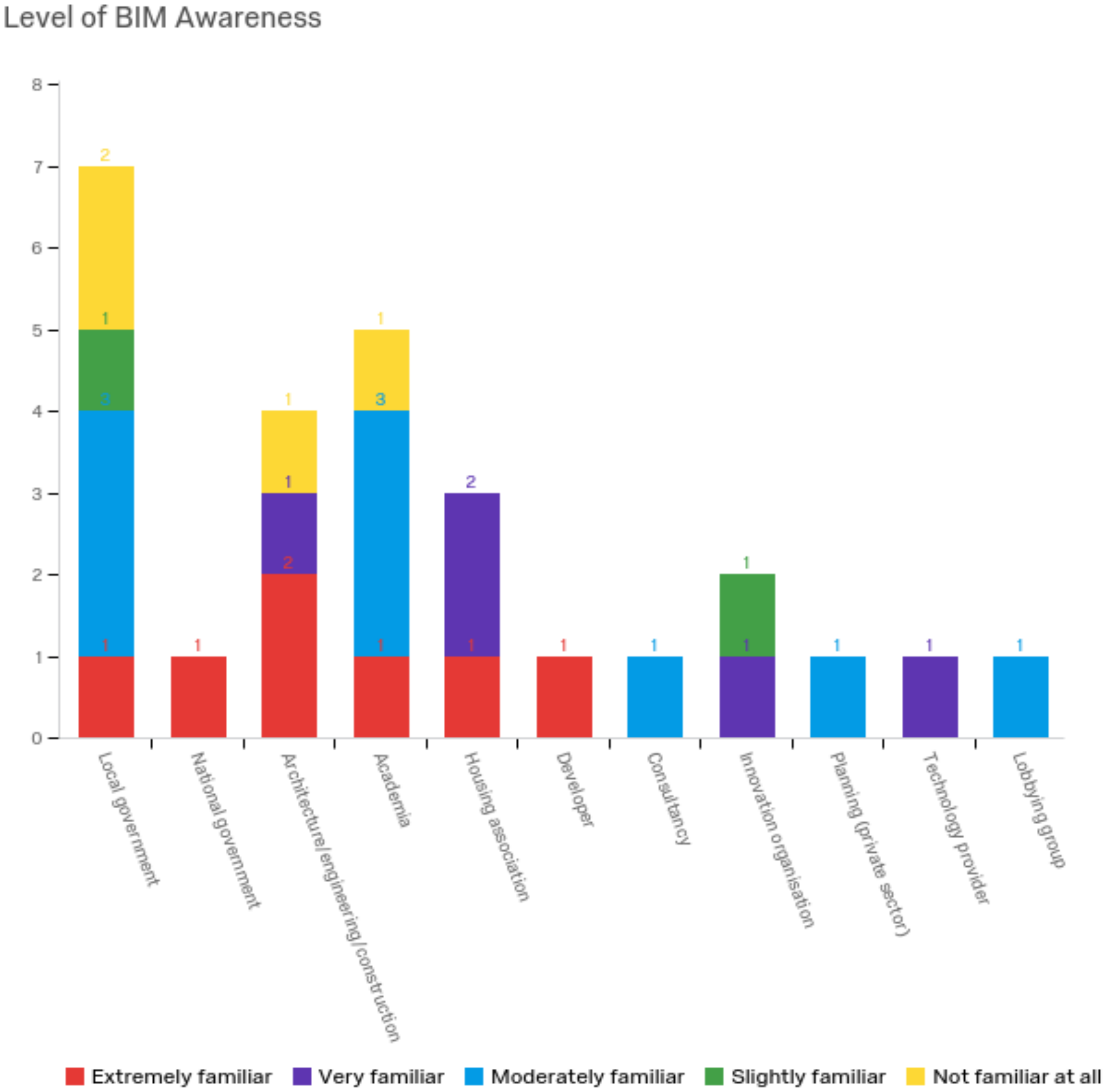
Source: own elaboration

Stakeholder engagement with BIM

When measuring the level of familiarity with BIM, we found that overall, our respondents felt fairly well informed, with only around 25 percent of respondents indicating that they were only slight familiar or not familiar with BIM (Figure 30). However, this overall analysis masks variation between respondents' fields. Looking at responses broken out by fields confirms previous findings that BIM awareness in local government is low (Sielker and Allmendinger, 2018), while at the national government level, it is high. This finding is mirrored when looking at what types of organisations use BIM: only 14 percent of local government respondents said their organisation uses BIM, while 100 percent of developers, national government, and AEC-affiliated respondents indicated their organisations used BIM.

Probing to understand how organisations are currently using BIM, we found that a number of respondents independently noted compliance with the BIM level 2 mandate in their responses, pointing to the power of government action to prompt adoption. While most respondents indicated they use BIM for design and construction, a private sector planning respondent indicated that they use BIM to create visualisations and representations of physical buildings to support planning applications and the planning process. This indicates that government may have an ally in private sector planners in catalysing BIM implementation in planning.

Figure 30



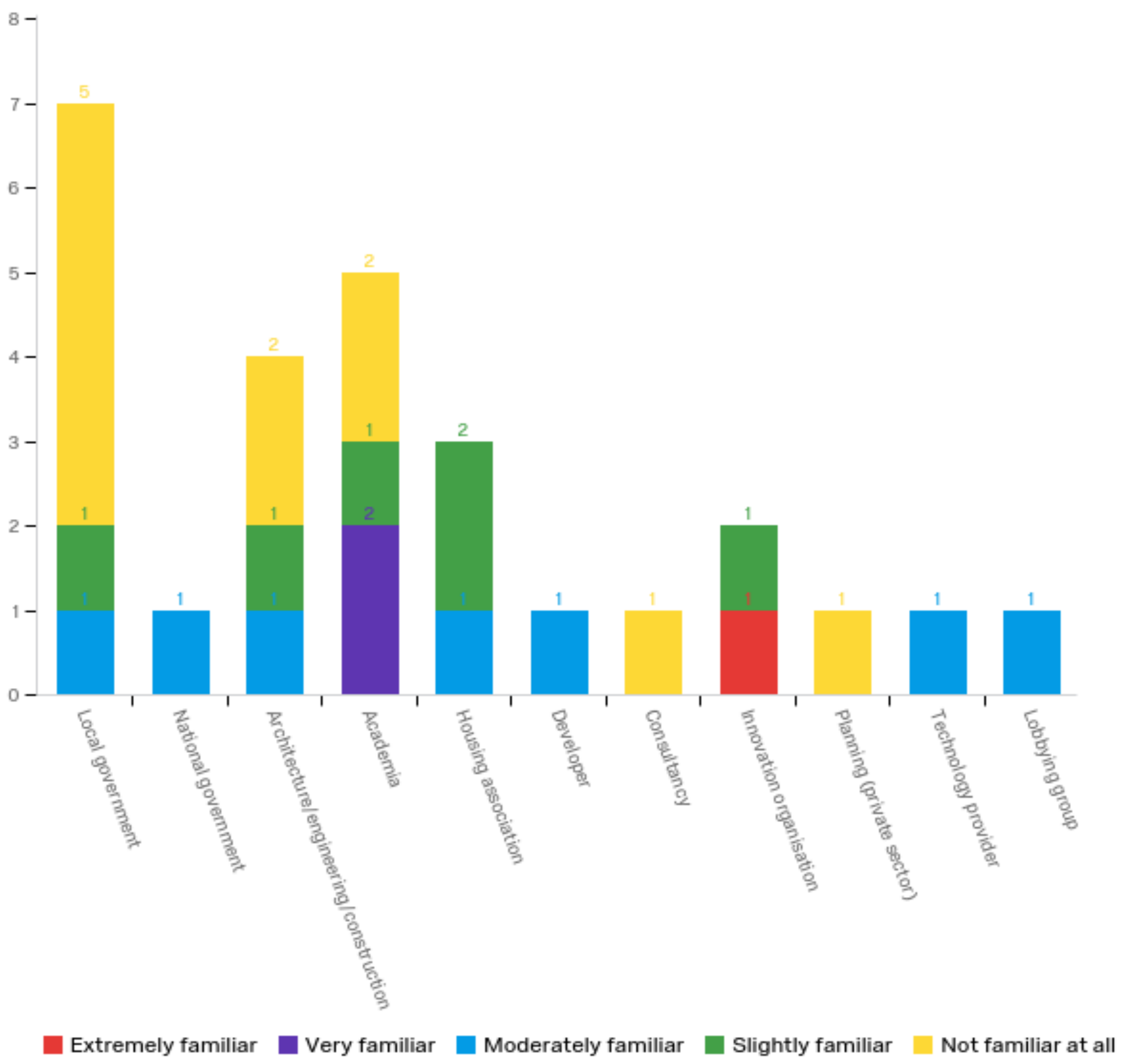
Source: own elaboration

Stakeholder engagement with CIM

Stakeholder awareness of CIM was much lower than of BIM. Whereas around 25 percent of respondents were not familiar or only slightly familiar with BIM, nearly 60 percent of respondents have little or no familiarity with CIM (Figure 31). Of particular note, local government and private sector planners register very low levels of awareness. While this result is skewed by the low response rate from private sector planners, it may highlight a challenge in implementing BIM for planning. If those involved with planning are not aware of city-level information modelling, then likely their understanding of how BIM might support planning is limited, and if planners do not understand BIM's potential use cases, then adoption will likely be lower and slower.

Figure 31

Level of CIM Awareness



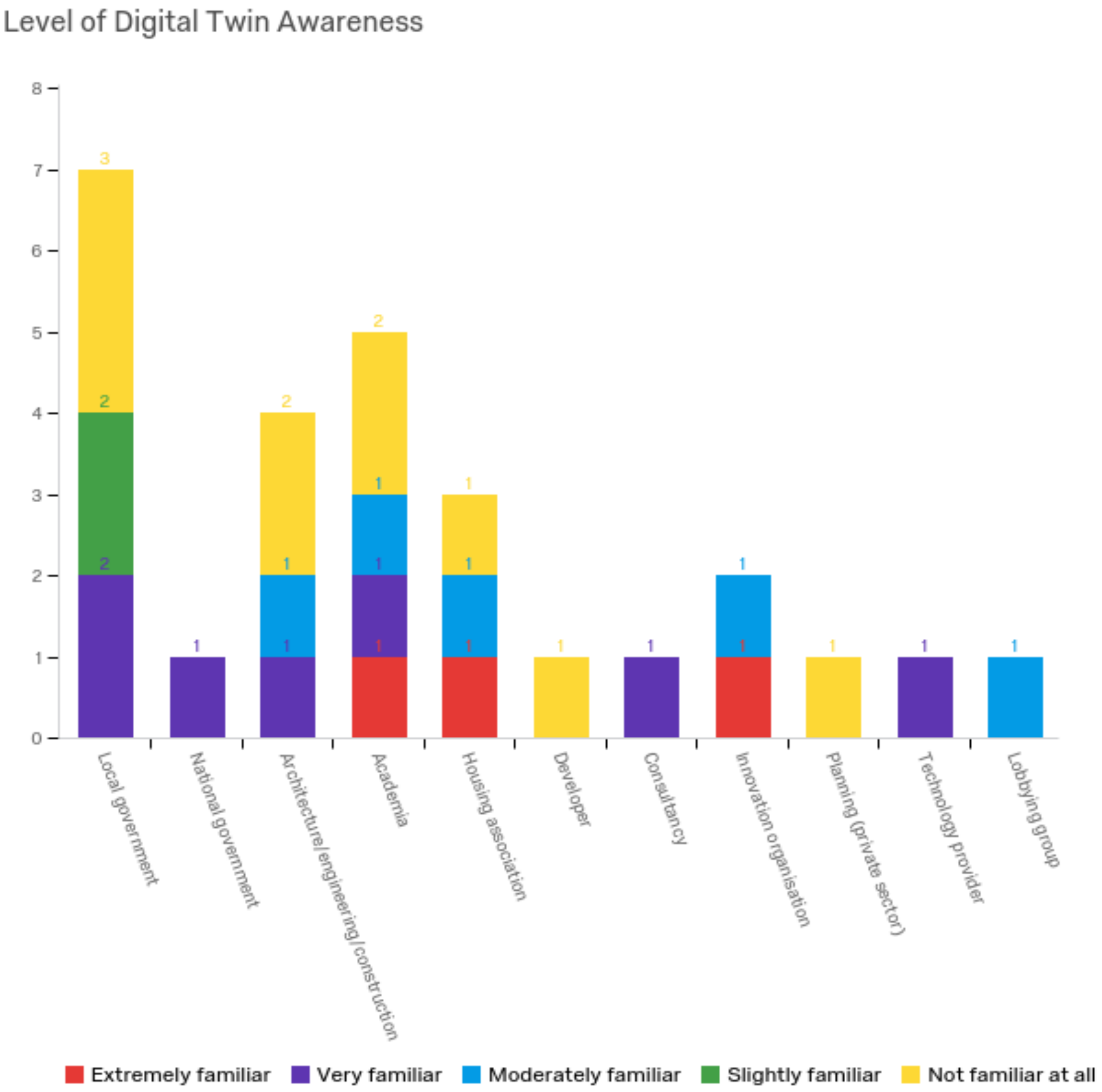
Source: own elaboration

Predictably, CIM usage across organisations was also low, with only two respondents indicating they use CIM. One respondent is involved in academia, and teaches CIM, and the other was a technology provider. This suggests that future planners may adopt CIM, and that the technology sector is awake to the potential for CIM software; however, to promote information modelling implementation for planning in the near term, it will be necessary to evaluate the benefits of CIM, and to educate users and beneficiaries around whatever benefits are uncovered.

Stakeholder engagement with Digital Twins

More respondents were familiar with digital twins than with CIM; however, awareness levels were still relatively low, with 50 percent of respondents indicating that they had only slight or no familiarity with digital twins (Figure 32). Interestingly, awareness of digital twins was concentrated in local and national government and housing associations, as well as in more expected areas, such as academia, technology providers and the AEC industries.

Figure 32



Source: own elaboration

Around 30 percent of respondents indicated that their organisations use digital twins. These respondents were concentrated in local government, academia, consulting, technology provision and innovation. Respondents noted using digital twins to pilot the capacity of utility networks, to model town centres for stakeholder impact assessments, to support maintenance and operations in the rail sector, and in teaching.

4.4. Use cases: opportunities for information modelling in planning

4.4.1. Stakeholder perspectives: future uses of BIM in planning

As information modelling has not yet been broadly applied for planning purposes in the UK, part of this research was focused on understanding what needs planners have from digital tools, and whether information modelling has a role to play in addressing these needs. Analysis of stakeholder interviews and questionnaire data indicates that stakeholders want to use BIM technologies for three main purposes: 1) creating a 3D city model, built on individual BIMs; 2) maintenance, operation and effective asset management; and 4) information modelling for collaboration.

1. Information modelling for a city model – stakeholders want a model for scenario planning, where they can model changes to see impacts on things like jobs delivered, square footage created, land use, developments delivered, types and numbers of homes delivered, air quality, traffic flow, energy use and planning requirements like height or density requirements, and future plans (e.g. for transportation investment). There was also some interest in using this type of model for public engagement and assessing visual impacts of projects, though this is complicated by the added work it could create for already time-poor planners.

   There is interest in being able to drop BIM models into the city model, which could then help with the planning assessment. Essentially, information from a BIM submission could feed directly into planning applications, to automate validation. It is hoped that this would improve the quality of information received from applicants and also reduce processing times for validation and registration, while also 'outsourcing' the creation of a city model.

   There was hope that this model would be able to incorporate and support smart buildings, smart bus routes, and smart parking services, etc. There was a desire to link some of this type of information to apps to enable a better resident experience.

   Our analysis indicates that a tool such as this would need to have a UI available that is as easy to interact with as Google Streetview, and must have the right level of detail to make it feasible and adoptable. This would facilitate uptake and adoption across the related departments that would need to feed information into and would benefit from such a model.

2. Information modelling for maintenance, operations and infrastructure management – stakeholders needed better historical data on assets in the built environment, and BIM was seen as a way to ensure that accurate information about assets could be transmitted, delivering cost and time savings, and making upkeep cheaper. This is applicable to assets both above and below ground.

   Additionally, some transit agencies are considering ways to manage their infrastructure systems through BIM. Bristol already has a BIM strategy in place to support their highways, and several local authorities expressed interest in developing a BIM system to provide insight on assets that are underground.

3. Information modelling for collaboration – the job of the planner is to lay out blueprints for the future development of their communities. However, our research showed that planners are often making local plans without the information they need from areas responsible for education, for example, or health. Information modelling was seen as a way to facilitate the kind of collaboration necessary to facilitate more strategic, joined-up and realistic plans.

4.4.2. Outputs stakeholders want from digital planning tools

As outlined in section 4.3 on current levels of stakeholder awareness, knowledge about information modelling is not high in many local authorities. Therefore, in addition to investigating what information modelling can to do enable better planning outcomes, we also investigated general pain points that planning stakeholders experience, and queried the role that technology in general can play in addressing these challenges.

Respondents were interested in getting a diversity of benefits from planning tools. Below, we break out the desires expressed by stakeholder group:

- *Local government* wanted improvement in the long-term performance of the buildings they design, easier and cheaper plan making with better citizen engagement, and 3D models that make it easy to understand the impact of new development, both visually and also in terms of impacts on transport, air quality and energy.

- *Devel*opers wanted to be able to pass useful information generated during the construction process on to owners and occupiers, though they noted that there is at present no financial reason to do this, and no clear value proposition to them for doing so. In this application, digital planning tools could potentially support the creation of a "golden thread" of good quality information, called for in the Hackitt report, to ensure future building owners can better manage building safety (2018). However, it will be important to ensure that information modelling for planning stays at the right level of detail to facilitate its use and uptake.
- *A private sector planner* indicated a desire for a means to share information easily across organisations, standards, software interoperability, and greater mapping of policy and spatial constraints across local authority areas.
- *Members of the AEC industry* wanted information modelling to facilitate a greater availability and use of open sourced datasets that are updated throughout the lifecycle of a project to support spatial and master planning.
- *Housing associations* were interested in easy-to-use tools to assist project teams in planning sites that then provide clear and credible data for future teams and feedback. They also wanted a digital planning tool to provide them with restrictions and site requirements.
- *Other stakeholders* mentioned a desire to have digital tools that can automate low value add tasks, and enhance transparency in decision-making.

As the summary above indicates, stakeholders in the planning system have diverse desires when it comes to what they want from digital planning tools. However, the expressed desires are congruent, and in the main want to support better asset creation and management in the future and improve the efficiency and transparency of the planning application process.

4.4.3. Data and information stakeholders want integrated into BIM for planning

While the outputs that stakeholders want from digital planning tools varied considerably, ideas about the information desired from a BIM model for planning were more unified, with local government, developers, and private sector planners articulating similar visions.

- *Local government respondents,* when asked what information they would want from information modelling for planning, indicated a desire for a 3D model that would integrate into a digital twin of the building's context and surroundings, and would contain information about a building's design scheme, planning history, and planning constraints. Interestingly, this mirrored, at least in part, the desire of a developer respondent as well.
- *A developer respondent* articulated a wish for a BIM model that contains data about relevant policies and documents, uniting information from spatial development plans, local plans, and usual standards. The developer was also interested in a tool that would work out Community Infrastructure Levy and Section 106 payments, similar to the formulas that define contributions to education and open space.
- *Private sector planners* echoed these wishes, articulating a desire to incorporate policy and spatial constraints into building design and see the wider landscape.
- *Members of the AEC industry* wanted information related to Undertakings and Assurances embedded within the BIM model and kept live, rather than existing in a separate database.
- *Housing Association* respondents pointed to a desire for a rich information environment that is standardised.
- *National government respondents* indicated a desire to have information about the building's condition, maintenance history, location, size, weight, owner, price, manufacture, supplier and applicable standards. This desire was echoed by a technology provider
- *A technology provider* expressed a desire to have asset life span and service schedule for facilities management.

- *Other stakeholders* indicated a desire to use BIM to track outcomes, and compare them against promises made during the planning process, and using BIM to gather information on things like embodied carbon.

4.4.4. Successful digital initiatives

Our case study research illustrated that there are interesting digital planning initiatives taking place across the UK, and our questionnaire findings supported this insight. Some local authorities collaborated to develop a new BIM viability toolkit. National governments have undertaken projects with laser scanning, photogrammetry, BIM pilot projects prototyping new planning interfaces, and information mapping features. A private-sector planner has complied a comprehensive GIS-based database with consistent data on planning policy and spatial constraints, as well as publically available data from the Office for National Statistics and other UK-wide data. This database has no disparities between differing countries, regions or local areas. This last initiative is especially promising, as it starts to address the needs articulated by stakeholders.

Of particular note, Liverpool has been building a city model. When it started the model project back in the early 2000s, it was analogue, but it has since become a digital city model. This may provide a road map to over cities interested in creating a city model, showing that city models can be created through consistent investment over time.

4.5. Barriers to digitalisation and implementing information modelling for planning

Analysis of the stakeholder interviews highlighted a number of barriers to the implementation of information modelling for planning. Throughout the analysis, it became clear that barriers to digitalisation in general in local authorities represent barriers to implementing information modelling. In this context, digitalisation is understood as the use of digital technologies to fundamentally change work processes, as opposed to digitisation, which is understood as making a formerly analogue work process digital. As implementing information modelling for planning would represent an advanced form of digitalisation, any hindrance to digitalisation is likely also to be a barrier to information modelling. This understanding aided analysis of interview data, because as our research on stakeholder awareness indicates, many planning stakeholders do not have a high level of awareness when it comes to BIM. As a result, discussions usually pointed more generally to barriers to digitalisation as opposed to information modelling specifically.

Barriers from the interviews fell broadly into six categories: organisational barriers, data-related barriers, technological barriers, human resource barriers, financial barriers and legal barriers, as shown in Table 14 . Note that the examples listed in each barrier category are meant to be illustrative and are not exhaustive of all the barriers in that category.

One of our important findings was that barriers are always highly interlinked, with, for example, organisational barriers leading to data-related barriers, or financial barriers leading to human resource barriers. Often, barriers could be classified under multiple headings. For example, stakeholders identified lack of awareness from senior members of their organisations as a barrier; this could be understood as both an organisational barrier and a human resource barrier. Because senior members of organisations have organisation-wide impacts, this barrier was classified as an organisational barrier, but it clearly also has a human resource side, and a human resource-orientated solution may be useful in overcoming this particular barrier.

To better understand the extent of perceived challenge each type of barriers presents to stakeholders, we asked stakeholders to rate how challenging each barrier type was in their organisation (Figure 33). Results showed that stakeholders rate organisational barriers as the most challenging, with around half of respondents labelling them as very or extremely challenging. Respondents also indicated that data-related barriers were significant challenges, with nearly 40 percent of respondents labelling them very or extremely challenging. Our stakeholder interview analysis confirmed these finding, as the areas that had appeared most often in the interview coding analysis were related to organisational and data-related barriers. As the graph below shows, respondents find most barriers moderately challenging. This points back to the fact that the barriers to digitalisation are highly interrelated: there is not one incredibly challenging barrier that dwarfs the importance of other barriers. Rather, many barriers are moderately challenging, so implementing information modelling will require a multi-pronged approach that tackles multiple barriers at once.

Table 14:

Types and examples of barriers to digitalisation and information modelling for planning

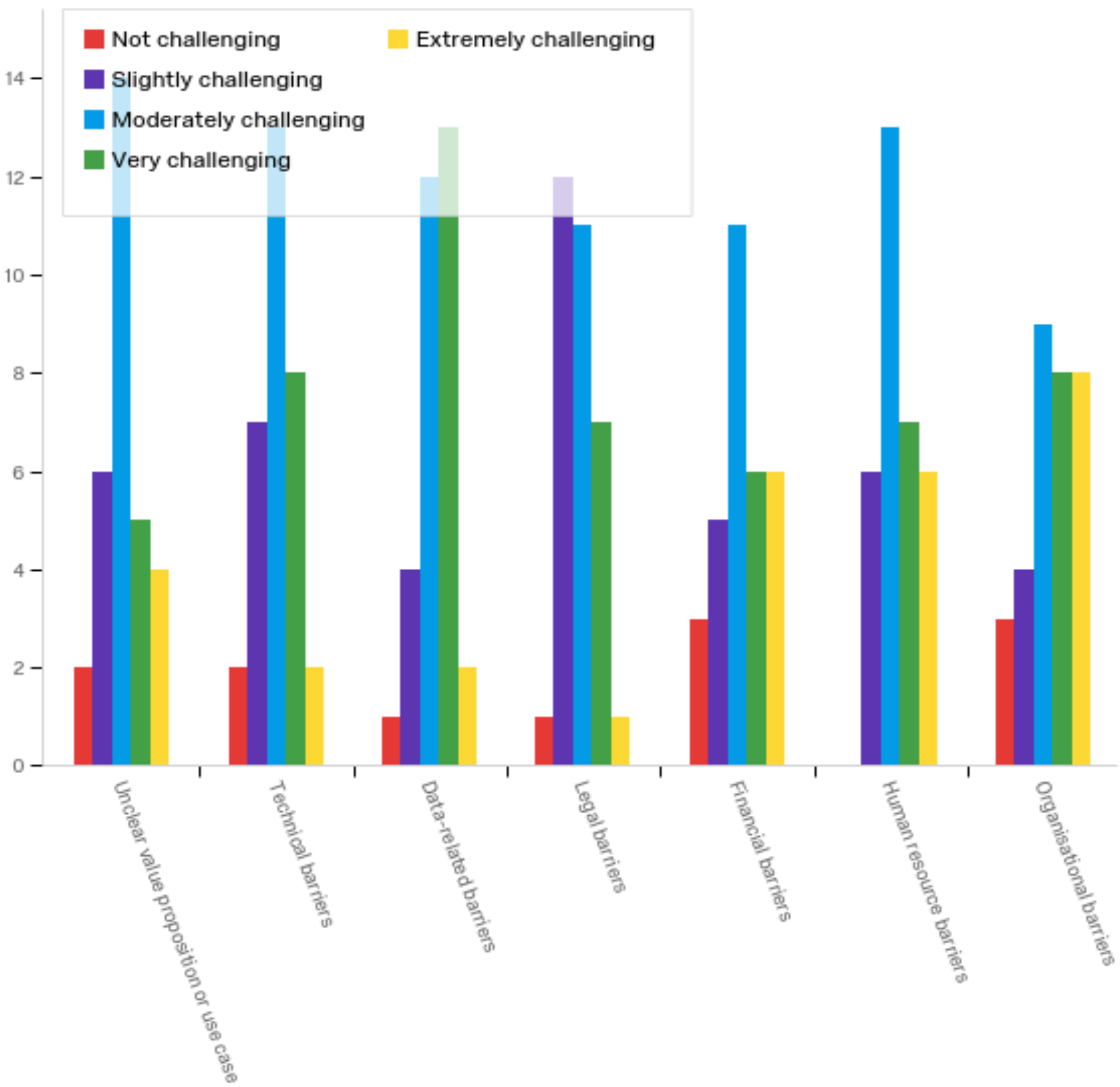
Organisational	**Technological**	**Data-related**
Fragmented government structures	Contract lock-in with technology platforms or providers	Necessary data difficult to access
Lack of leadership support	Lack of standardisation in tools and protocols	Data is not of good quality, validated or standardised
Unclear data sharing arrangements	Need for hardware upgrades	Level of detail in BIM is too high
Unclear information about existing data sets	Non-interoperable software systems	Insufficient data storage capacity
Human Resource	**Financial**	**Legal**
Lack of in-house expertise	Hardware and software upgrade costs	Uncertainty around what can legally be shared
Lack of technical and legal training	Cost of hiring right personnel	Time-consuming nature of getting legal approval for sharing
No time to get up to speed	Data storage costs	Insurance and liability concerns
No time for implementation processes	Training costs	GDPR and other data privacy laws and regulations

Source: own elaboration

The remainder of the discussion and analysis section focuses on analysing each individual barrier category, combining insights gained from the in-depth stakeholder interviews with findings from the questionnaire to paint a holistic picture of the range of barriers to information modelling in planning.

Figure 33

Level of challenge posed by barriers



Source: own elaboration

4.5.1. Organisational barriers

Organisational barriers represented the highest barrier to information modelling in both the stakeholder interview analysis and in questionnaire results. However, stakeholder interview analysis as well as case study analysis pointed to fragmented governance structures as the most influential type of organisational barrier, whereas the questionnaire indicated a lack of awareness from senior organisation members as the strongest impediment. Significantly, stakeholders also emphasised that organisational change takes time, and marked out this by itself as a barrier to information modelling for planning. As respondent opinions regarding the most challenging organisational barriers were highly fragmented (Table 15), the remainder of this analysis is organised to focus more on findings uncovered through stakeholder interviews and case study analyses. As the analysis below illustrates, governmental fragmentation is a root cause for many other types of barriers, including data-related and financial barriers.

Table 15: Organisational barriers to digitalisation and implementing information modelling

Challenge	%	Count
Lack of awareness from more senior people in my organisation	11.32%	18
Unclear data sharing arrangements	10.69%	17
Lack of collaboration between departments within my organisation	9.43%	15
Unclear work flows	8.81%	14
Unclear information about existing data sets	8.81%	14
Fragmented local-regional governance structures	6.92%	11
Responsibility for data management does not rest within particular roles, groups or departments, or no one is available to manage the exchange of data	6.92%	11
Lack of collaboration between different governmental bodies	6.29%	10
Lack of awareness from colleagues	6.29%	10
Lack of leadership support	5.66%	9
Competing priorities	5.66%	9
Lack of awareness from politicians	5.03%	8
Political disagreement	3.77%	6
N/A - my organisation does not face organisational barriers	2.52%	4
Unsure	1.26%	2
Other	0.63%	1
Total	**100%**	**159**

Source: own elaboration

Governmental fragmentation in planning

Analysis of our interview data highlighted governmental fragmentation as one of the primary barriers to digitalisation and the implementation of information modelling in planning. Planning necessarily involves considerations about building control, roads, bridges, schools, energy, waste management, healthcare facilities and a host of other topics in interrelated sectors. However, the planning systems in the UK do not fully integrate these separate sectors. This makes it difficult to realise the benefits of strategic planning and represents a barrier to implementing information modelling for planning, as information modelling requires data and buy-in from many planning-related sectors.

For example, when planners draw up local plans without adequate information about what the education department plans to do or can fund, the local plan runs the risk of creating housing in areas that cannot support more schoolchildren. If planners do not have access to forward-looking information from relevant sectors, then the local plan they produce will be a less useful document, and will result in difficulties later, with contested development sites, and contradictions between what the local plan calls for, what is logical and feasible for a community, and what council members can support. This leads to a vicious cycle: if local plans are not a trustworthy blueprint for a community's future, then it is difficult for planning to be a unifying strategic visioning process, making it more a tick-box development control exercise. If planning becomes a tick-box permissions exercise, then it is not included in important conversations about the future of a community. For example, in one of our case study local authorities, planning did not feature once in the council's new corporate strategy, despite the fact that planning will be involved in almost all of the functional areas of the strategy.

In local authorities with more complex governance models, the quagmire is thicker. For example, different governmental bodies controlled by different political parties may share jurisdiction over transport planning and housing. Clearly, transport planning for interlinked economic areas must take a joined-up approach and planning for housing has to go hand-in-hand with transportation planning, or one risks having poorly connected housing development. Keeping intimately related spatial concerns separate leads to inefficiency, and slows the planning process. This level of fragmentation means that not only is it hard to take a strategic perspective on plan-making, and that there is no strategic, joined-up perspective on the growth and trajectory of the built environment, but also that different bodies use different software and hardware, have data silos, and struggle with procurement challenges as detailed further below.

As there are many different governmental bodies involved with planning, there is no single joined up information source for planning, which challenges departments that rely on related information, and developers, who may need to perform several dozen different searches to understand the planning considerations for a site. The lack of a joined-up information source on planning-relevant information also presents a major obstacle for the implementation of information modelling for planning.

Organisational barriers to effective procurement

Organisational barriers like governmental fragmentation can also lead to procurement and financial issues. Briefly, each authority does its own procurement (and often different departments make procurement decisions separately), and the procurement process is difficult. Because of individual procurement decisions, authorities and departments may have different systems that are not interoperable, or may be running on different versions of the same system. With systems that are not easily interoperable, it becomes hard to share information across departments and authorities. The value of information modelling is lost if information cannot be joined up. Individual procurement arrangements also pose barriers to information modelling for planning because it can lead to financial challenges as well. Because individual authorities and departments are relatively small, they do not have strong bargaining power when contending with software and hardware providers, and cannot take advantage of joined-up bargaining or economies of scale. This makes acquiring systems more expensive, and as we show in section 4.5.5, financial barriers are a significant impediment to information modelling for planning. Fragmentation can also lead to duplicated efforts at innovation, and make it hard to scale solutions.

In addition to challenging planning departments internally, governmental fragmentation also creates challenges to the innovation environment surrounding planning, which further challenges the uptake of information modelling for planning. Companies find it difficult to innovate for and contract with local authorities. The local authority market is so fragmented that innovators report it actually acts as a deterrent to market entry. The prospect of having to go through arduous individual procurement processes with the over 300 local authorities in the UK alone makes creating innovative products and services for local authorities unappealing to private companies. Market issues around innovation for the planning sector are covered in greater detail in section 4.5.3 below on technological barriers.

Government fragmentation and politics in planning

This study breaks down the category of policymakers, differentiating between elected officials, like council members, and unelected public workers, like planners. In the English planning system, elected council members are responsible for setting budgets. This means that unless local politicians prioritise digitalisation in the planning system, planning authorities will not receive the budget to make the hardware, software, and training investments necessary to support information modelling for planning. The more complex the planning governance structure is, the more difficult political forces can be. For example, in combined authorities and areas with shared planning services, there might be political divide between councils, which makes agenda setting difficult, as opposing political parties will need to come to an agreement on planning policy objectives and funding decisions. This presents a particularly big challenge for large ticket purchases, like 3D modelling software and new hardware.

Data silos

While data silos represent a data-related barrier, we cover them here, as well as in the following section, to highlight the role that organisational barriers can play in creating them. Data silos are problematic for a number of reasons. They can lead to inefficiencies, as different parts of the government redo the same analyses. They reduce the value of data, because they make it difficult to join up datasets for improved insights. Organisational fragmentation can also lead to and reinforce a lack of standardisation in data handling and management protocol, which then makes it more challenging for inter-silo sharing, as each working group typically develops their own data management conventions. This often means that valuable information that one part of a governmental body captured is not passed along to other departments or parts of government that would benefit from that data.

Fragmentation also narrows the interests of involved departments or organisation. With constrained budgets, it is difficult for a department or organisation to justify collecting and sending off data to another department or organisation if it does not directly contribute to executing on the first department or organisation's mandates. In a related vein, the expectations for and financial model behind data sharing is not yet clear, and some departments want to try to monetise their data. While this might provide a source of revenue to local authorities, it also might make information modelling for planning more challenging, if it becomes expensive to access the necessary data.

Lack of sharing systems

Many organisations lack a common data environment and formal arrangements to facilitate data sharing. While some local authorities, like Highland in Scotland, have focused on building out their digital architecture to facilitate sharing, some authorities still share data via CDs. Information modelling will require more sophisticated data-sharing methods, so local authorities will have to upgrade their systems. Organisationally, data-sharing processes are also missing. Individuals and departments rely on interpersonal relationships to get the information they need. For example, in Bristol, when planners need tax data, they will lean on interdepartmental connections they have, as there is no formal exchange set up. Similarly, although Cambridge has a combined planning authority, data sharing between the City of Cambridge and South Cambridgeshire has not been routinized and relies on more ad-hoc exchanges at present. These patterns are not unique to local authorities: Historic Environment Scotland also notes that a lot of important property information is held locally, at times just in the heads of on-site managers. While ad-hoc data sharing is sufficient to enable low levels of digitalisation, implementing building information modelling for planning will require more formalised data sharing.

Organisational culture

While data sharing is necessary for digitalisation and information modelling, multiple interviewees noted a cultural resistance to data sharing. Two main drivers were identified for cultural reluctance to share. First, data is seen as valuable, and so cash-strapped local authorities may be interested in trying to monetise their data, which makes them less likely to share information freely, even with other governmental bodies. Second, legal concerns hinder data sharing. There are many laws and regulations that govern data sharing, which pose a separate challenge to information modelling for planning, and are covered in the legal barriers and human resource sections below. Some organisations have poor legal knowledge and are understandably risk adverse. Uncertain what legal requirements apply to data sharing, they opt to not share, rather than risk breaching the law and sharing data they should not have.

Lack of awareness from senior leaders and politicians

Our interviews and questionnaire data confirmed that a lack of awareness from organisation leaders and policymakers can block moves towards digitalisation. In both instances, the barrier is grounded in resource allocation decisions. Local council members are responsible for setting budgets, as is discussed below, and if they do not see the value in allocating budget towards the hardware, software, personnel and training required to support digitalisation and information modelling, these initiatives will not move forward. Similarly, senior members of organisations must see the business case for enabling digitalisation to support programming and personnel for these endeavours. This also points to the need for strong leadership in support of digitalisation. Multiple stakeholders explicitly expressed a need for a leader to take on digitalisation, and for leadership vision around using digital tools.

4.5.2. Data-related barriers

Our analysis revealed a significant number of data-related barriers to digitalisation and information modelling for planning (Table 16). Our questionnaire indicated the top four data-related barriers are that: (1) data is not standardised; (2) respondents cannot access the data they would like to use, even if it exists; and a tie for (3) between data being of poor quality and the data not being validated. For a further breakdown of data-related barriers, see Table 16 below. Deeper analysis of stakeholder interviews added nuance and flagged up a common theme across data-related barriers, tied to the ability to share data. As mentioned above, the ability to share data is linked to organisational barriers, as well as technological barriers covered further below.

Table 16: Data-related barriers to digitalisation and implementing Information Modelling

Challenge	%	Count
The data is not standardised	20.22%	18
The data we would like to use exists, but we cannot access it	15.73%	14
The data is not of good quality	13.48%	12
The data is not validated	13.48%	12
The data we would like to use does not exist	7.87%	7
The level of detail in BIM models is too high	6.74%	6
The data is not machine-readable	5.62%	5
We are unable to work with large files	5.62%	5
We do not have the data storage capacity	4.49%	4
Unsure	4.49%	4
N/A - my organisation does not face data-related barriers	2.25%	2
Total	**100%**	**89**

Source: own elaboration

Standards and level of detail in BIM for planning

Interviews confirmed the findings of our questionnaire, highlighting the need for standardisation in how data is captured and recorded, and consensus on what information is required for the planning system. One theme that played prominently across interviews was the idea of “BIM lite”, a BIM model striped of the architectural details not necessary for planning, and consisting of only data relevant to planning. Planners argued that they did not need to know what kinds of screws were used in a build process, and that having such a level of detail would slow down their computer systems. Bristol reported having received some BIM models, but that the process of stripping out the unnecessary details from the model was so time consuming it is deemed not worthwhile. This indicates a need to establish industry-wide standards about what information is required in BIM for planning, and what level of detail is appropriate for information modelling in planning. At the same time, a housing association stakeholder highlighted the lack of standards at the base level of information requirements. At the product level, product data templates are not available, which limits involving the full supply chain. Some balance regarding the level of detail on BIM models for planning will be necessary to ensure information modelling for planning relevant to a range of planning stakeholders. This is particularly important, when thinking about the role that the planning system can play in actualising on some of the recommendations contained in the Hackitt report (2018). In particular, what level of detail is appropriate to ensure safe buildings and while also facilitating easy use of a “BIM lite” approach to information modelling for planning.

Data-sharing

Our research highlighted that often organisations and departments cannot strategically use data because of difficulties related to data sharing. This finding is congruent with the survey data, which pointed to an inability to access data, even if it exists, as the second most challenging data-related barrier to digitalisation and information modelling for planning. Difficulties in data sharing represent a formidable barrier to information modelling because information modelling creates value by joining up sets of information. The section below enumerates some of the challenges related to data sharing that were common across geographies and planning stakeholder sectors.

Our research indicated that often developers do not share the data or models they have on a building site or an area with local authorities, even if the project benefited from public sending. Similarly, some stakeholders felt that planning consultancies sometimes intentionally make data they produce and compile for authorities hard to find or comprehend, as this helps create dependency on the consultancy and ensures further work. Data flows to the public sector, particularly if the public sector supported the creation of the data, will be important to enabling information modelling. If strong data sharing arrangements are put in place, there is the potential to at least partially outsource the creation of a city model that can provide the basis for a digital twin or CIM.

Data silos

Many organisations and departments have data silos, which was referenced in the section on organisational barriers. Due to data silos, at times departments do not know where in their organisation data exists, and the part of the organisation that holds the data is not the part that needs it. Without systematic exchange built into working practices or digital architectures, identifying where information is and how to use it is difficult. For example, Cambridge recently conducted a transport data audit in order to ascertain where transport-related data existed. They discovered that they have real-time bus data that could answer councillor's questions about where bottlenecks are in bus service, but that those data feedback loops were not set up. Additionally, the Scottish Government noted the need to do a planning data inventory to understand what data they had available in order to set design processes for the future. Data silos create and compound challenges in extracting value from data for public benefit.

Analysis of data silos also highlighted the role that governmental fragmentation can play in hindering data flows. For example, in Cambridge, the Cambridgeshire County Council had been the transport authority and so held most of the transport data; however, the Combined Authority became the new transport authority, which complicated questions around who holds transit data. However, even in local authorities with well-integrated governmental structures such as Bristol, interviewees noted they experienced data silos.

As mentioned earlier in the organisational barriers section, legal uncertainty regarding how to share data while complying with the law can help create or maintain data silos.

Data quality and validity

Our analyses indicated that data quality and validation issues represent significant barriers to implementing information modelling for planning, and the questionnaire confirmed these findings. Concerning data quality, stakeholders reported that without set standards, data recording practices are not uniform enough to make joining up information sources feasible. These issues are amplified as the number of departments or organisations contribute to a data environment increases because of differences in data management conventions and software providers, which links with technological barriers covered in section 4.5.3 of in this report. Across our case studies, interviewees also reported that sometimes the needed spatial and planning data was not clean enough to be useful across systems, that finding necessary data was time consuming, and that sometimes the necessary data was in paper format. Furthermore, some planners reported that the level of disaggregation in current data from sources such as the census was not high enough to be useful in a detailed 3D city model.

Relating to data validity, if the validity of data cannot be trusted, then governments and private sector companies cannot take action based on it. This can lead at times to duplicated efforts. Large AEC firms reported that they sometimes could not use public sector data because it comes with a "health warning" stating that it is for information purposes only. The issue of data validity is linked to legal barriers to information modelling (section 4.5.6), as liability issues regarding who is responsible for keeping models and data verified and up-to-date can hamper moves towards collaboration and BIM for planning. There is also an added danger to using data that has not been cleaned and validated in a BIM context, because it can slow down models and make them unstable. This underscores the need for high quality, validated data, and links back to finding the right level of detail for BIM models for planning.

Data and the planning system

The discretionary nature of the planning system may not, at present, facilitate meaningful exchange of data between applicants and planning authorities. Often in discussions about creating an information modelling system for planning, the assumption is that planning applications can be submitted in BIM format, and that these applications would then be used to populate a CIM for a local authority, which could also be joined up on a national scale. However, when applicants submit planning applications, they are not likely to have produced realistic BIM models of their proposed development, because they are not sure they will get permission. Only later in the process, once permission is granted, do developers and others invest in realistic BIM models, as a way of protecting against risk. If developer BIM models are to feature into a system of information modelling for planning and CIM, planning systems must be sure to collect BIM models that present real representations of what is to be built. This may require collecting BIM models through Building Standards, or altering some procedures in the planning process.

Interrelation between data-related barriers and other barriers

Because a rich information environment is crucial for building information modelling, many of the barriers to implementing it for planning are tied to availability and use of data. For example, Historic Environment Scotland (HES) has strict IT policies and procedures, and typically does not allow third parties to access their servers, which can make it difficult to find data management partners, and can sometimes hamper the flow of data from architects, surveyors and the like into HES's systems. This is both a data-related challenge, and a legal challenge. Similarly, as is detailed in the financial barriers section, some local authorities are worried about the costs of storing large BIM files, as data storage is expensive for them. This illustrates how a data-related question about the size of BIM files for planning relates to financial barriers that can block information modelling for planning.

4.5.3. Technological barriers

The top three technological barriers are that: (1) it is difficult for organisations to adopt new technology; (2) there is a lack of standard tools or protocols, and (3) that software systems are not interoperable. For a further breakdown of technological barriers, see Table 17 below. These results further highlight the interrelation between barriers, as the lack of standard tools and protocols is also tied to data-related barriers. For additional analysis of how the lack of standard tools and protocols impedes implementation of information modelling for planning, please see the data-related barriers section above. Our analysis of stakeholder interviews triangulated with our questionnaire findings, highlighting the difficulties of adopting new technologies, and the challenges presented by non-interoperable systems. However, our stakeholder interviews provided deeper insights. As the Scottish Government's experience demonstrates, current BIM technology is not prepared to facilitate integration into the planning process, and our case study analysis revealed that some of the drivers behind the strongest issue areas, as indicated by the questionnaire, were actually driven by challenges that had lower rankings in the questionnaire data. For example, lack of interoperability can also be related to technology lock-in. Below these issues are all explored further.

Table 17: Technological barriers to digitalisation and implementing Information Modelling

Challenge	%	Count
It is difficult for my organisation to adopt new technology	15.29%	13
Lack of standard tools or protocols	14.12%	12
Software systems are not inter-operable	12.94%	11
We are locked into a relationship or contract with certain technology platforms or providers	11.76%	10
We would have to upgrade our hardware	10.59%	9
Software connectors do not work well	8.24%	7
Technology partners are difficult to work with	5.88%	5
It would slow down our system too much	4.71%	4
Unsure	4.71%	4
Other	3.53%	3
N/A - my organisation does not face technological barriers	3.53%	3
The technology does not exist	2.35%	2
Lack of customisable tools	2.35%	2
Total	**100%**	**85**

Source: own elaboration

Adopting new systems

Organisations struggle to adopt new technology for a number of reasons. Some of these are related to organisational and personnel issues, which are covered in the sections on organisational barriers and human resource barriers, respectively. However, some barriers are more specifically focused on technological issues. For example, several stakeholders mentioned the opportunity cost of adopting newer systems. This can cause downtime for up to a week, which is unacceptable to some local authorities. Furthermore, as local authorities become more digitalised, they become more vulnerable to software and hardware outages, as well as internet threats. Recent attacks on local governments, such as the hacking in the US city of Baltimore, highlight the crippling impact that cyber threats can pose to for local authorities (Durkin, 2019). Local authorities have to figure out ways to mitigated against outages and threats in a cost-effective manner. Cambridge recently experienced a prolonged period of downtime and lost data as the result of an outage. Unfortunately, there were no viable system back-ups, so the system had to be restored manually, which took time. Adopting new technology systems, and particularly transferring to more digitalised ways of working, poses new challenges and threats to organisations that must be handled to support the roll-out of information modelling for planning.

Multiple stakeholders in local authorities and higher levels of government mentioned the need to upgrade to hardware that is newer or more powerful to be able to run new software. In specific relation to BIM, much of the legacy technology that local authorities use cannot accept BIM files, and reportedly cannot handle files sizes larger than 5 megabytes. Upgrading hardware and software, however, requires a financial investment and in local authorities, councillors typically make budget decisions. Therefore, councillors must see good cause to allocate money to the upgrade. For more details on these types of challenges, please see the sections on organisational barriers above and financial barriers below.

Lack of interoperability and technology lock-in

Interoperability is a theme that plays across the challenges. Data challenges relate to interoperability issues as interoperable systems make data sharing difficult and organisational barriers can enhance interoperability issues, as different parts of an organisation make software decisions independently. The lack of open source software was an issue that came up across the stakeholder interviews. Many providers of planning software have not accepted open standards as a norm, which challenges interoperability. This lack of interoperability can help lead to technology lock in, as it can be difficult to extract information from one system and input it into the next. Even when local authorities use the same systems, their information outputs may be non-interoperable, as different local authorities use the same systems in different ways. Stakeholders reported modifying functionalities of their Idox systems using SQL coding to be able tailor the systems to meet their working practices. While flexibility is necessary to ensure that systems can meet the needs of individual local authorities, some level of standardisation is necessary if information is to be interoperable across governance boundaries. The tension around striking the right balance between standardisation and facilitating ways for local authorities to customise to meet their needs is a theme that played throughout our interviews.

Finally, even within one organisation or department, many management systems may be in use. For example, both Historic Environment Scotland and Transport for London use multiple systems to manage their assets that are not necessarily integrated. To implement information modelling for planning, there would need to be a way to bring together information from disparate systems.

Functionality and technology partners

Beyond interoperability, there are some functional barriers to digitalisation and implementing information modelling for planning. As mentioned above, the Scottish Government's experience indicates that current BIM technology is not prepared to facilitate integration into the planning process. It may be necessary to develop planning-specific BIM tools in order to overcome this barrier. One stakeholder noted that in general the digital systems their organisation uses do not meet their needs, their hardware does not cope with the amount of data they use, and is slow and frequently crashes. Stakeholders reported difficulty in querying databases, and some planners pointed to the lack of a bespoke BIM tool for planning. Planners also reported dissatisfaction with some of the technology that they currently use for digital planning application management.

Local authority stakeholders frequently mentioned Idox as something that troubled their work, although stakeholders also praised it for enabling mobile ways of working. Idox is a software that can manage planning application documents for local authorities, and has over 90 percent market penetration for local authorities in the UK. Stakeholders reported wanting customisable fields, better customer support and feed-through integration between Idox and Uniform, which is Idox back-office software. Because Idox and Uniform do not automatically populate one another, employees spend time manually uploading and naming files. There is also no feature to automatically locate a planning application geographically, so this too is done manually, which is time consuming. One local authority employee estimated that she would process application 50% faster if Idox were better integrated and she had to do less manual data entry. While local authorities may criticise Idox's functionality, several stakeholders mentioned that many local authorities do not use the software to its full capacity, and sometimes implement it poorly. This points to a need for training, addressed in more detail in section 4.5.4 below.

The integration in national systems such as the Planning Portal in England and ePlanning in Scotland can also cause difficulties. Stakeholders reported frustrations with the Planning Portal and ePlanning, in part because these centralised portals can interfere with integration between other systems at times. In particular, Scottish stakeholders emphasised how difficult it was for them when ePlanning came online in advance of eBuilding Standards. Some authorities rely on collaboration between these departments, and when ePlanning was brought forward before eBuilding Standards, integrated local authorities struggled. As mentioned above, this is a historical issue, as eBuilding Standards has been live for three years now. However, this once again points to the challenges mentioned above: securing funding requires a robust business case (covered in more detail in section 4.5.5 on financial barriers). Building a strong business case may require pointing to previous successes: in Scotland, support for eBuilding Standards was won in part due to the success of ePlanning. This highlights the tension, mentioned earlier, between incremental and iterative change, versus ensuring digital integration across departments from the beginning. As digitalisation progresses, striking the right balance between incremental advancement, and ensuring that technology continues to promote collaboration will be crucial.

Local authority stakeholders noted challenges with technology partners who over-promise and under-deliver. On case study reported being sold Bluetooth services that were meant to provide the city with an accurate estimate of bicycle and other traffic. However, the service could not adequately distinguish between cyclists and motorists. Instead, the service providers assumed that 10 percent of traffic was comprised of bicycles, which is inaccurate for the local authority. When technology partners over-promise and under-deliver, local authorities become wary of investing in new digital tools and services.

Finally, our observations highlighted that at times there may be a large gap between current levels of digitalisation in local authorities, and levels of sophisticated digitalisation that information modelling for planning may require. Overcoming these technological barriers may prove to be a sizable hurdle for many local authorities.

Customisability versus standardisation

One tension we uncovered in our analysis was between the desire for customisable solutions, versus the need for standardisation. Local authorities that struggle with a lack of customisability often resort to work-arounds, writing their own code or asking for certain forms in paper. As one local authority employee reported, *"We don't have any access to add our own forms, so we kind of work between two systems"* and make applicants submit forms in paper format. This presents challenges to data integration between authorities, digitalisation and the implementation of information modelling for planning. Clearly, local authorities want to be able to tailor their tools to their own unique needs and processes; however, some level of standardisation is crucial, if data is to be shared across departments and local authorities. The tension between customisability and standardisation is particularly acute when operating at the regional or national scale, and to deliver public value from data-driven insight, such regional and national initiatives must strike a balance between standardisation and customisability.

Market challenges

This barrier, like most, is an overlapping barrier that could be featured in the financial barriers section as well as this technologically-focused one. We have put market challenges in the technology category, as these market challenges stymie further technology innovation. However, as a market failure, this challenge also has relevance to the financial barriers section.

As mentioned above, Idox dominates the local government software market. This near monopoly can make local authorities feel trapped or *"held by ransom by Idox"* as one stakeholder put it. However, a series of conversations conducted by Jess Williamson for the Ministry of Housing, Communities and Local Government indicated that the local authority market is a challenging one for innovators to enter. Specifically, PropTech companies highlighted that the market is incredibly fragmented and barriers to entry can be significant. Would-be digital innovators for government point out they typically have to tailor their products to 300+ different local authorities, operating with different legacy systems and accustomed to different ways of working. This makes scaling innovation challenging. Securing contracts often requires negotiating and going through procurement processes with each individual council, and this adds a further hurdle. Additionally, getting a local government contract is viewed as a long and challenging process, with incumbents favoured by locked-in contracts.

The combination of a hard-to-enter and fragmented market makes focusing on the local government sector challenging for businesses. One London-based company switch from focusing on local government to focusing on serving private sector markets (e.g. developers) as it was an easier space to work in. This type of move may have significant ramifications for the balance of power in the planning system in the future. Information and data can represent power, and if developers and private sector actors have access to better systems to gather, process, and interpret data, then the power balance may tilt towards them and away from the public sector. These considerations can have a major impact on the development of systems for information modelling for planning.

Accessibility

Planning is a public-facing activity, and gains legitimacy from robust public participation. Therefore, any digitalisation within the planning system must further support public participation. Stakeholders both in Bristol and in Scotland flagged concerns around the accessibility of online planning to all constituents. As some areas in these geographies do not have strong broadband connections, there was concern that digitalising parts of the planning process, and in particular, incorporating large files into any public-facing element of planning, might reduce the accessibility of the planning process to local citizens.

While many planners we spoke with identified the ability to visualise a planned building in its local context in 3D as a benefit, we also came across three main concerns, regarding the use of 3D visualisations for planning. First, as mentioned above, there was concern that these files would be difficult for some members of the population to access. Second, some stakeholders expressed concern that even if community members could load the 3D models, they are not intuitive to navigate, and that it would make it harder for some community member to participate. Finally, there was concern that this type of public participation would actually add to the burden of planning authorities, who would then need to answer questions and concerns based on the 3D models, or be responsible for any issues, should the technology be faulty.

4.5.4. Human resource barriers

Human resource barriers represent a significant impediment to digitalisation and implementation of information modelling for planning. Consistent with findings from the stakeholder interview and case study analyses, the questionnaire indicated that the top three human resource barriers are: (1) a lack of in-house expertise; (2) lack of time to get up-to-speed; and (3) a lack of training. This barrier is clearly linked with the financial barrier around hiring the right personnel being too expensive and training being cost-prohibitive as well (detailed in section 4.5.5 below). For a further breakdown of human resource barriers, see Table 18 below. Respondents also noted that getting teams trained to use new tools is challenging, and may require a government mandate to accelerate uptake.

Table 18: Human resource barriers to digitalisation and implementing Information Modelling

Challenge	%	Count
Lack of in-house expertise	24.68%	19
Lack of training	18.18%	14
No time to get up to speed	19.48%	15
No time for implementation	14.29%	11
Difference in expertise among collaborating parties	16.88%	13
Other	2.60%	2
N/A - my organisation does not face human resource barriers	2.60%	2
Unsure	1.30%	1
Total	**100%**	**77**

Source: own elaboration

Four themes emerged from the analysis of stakeholder interview data that helped explain the findings of the questionnaire. Gaps around budget, staffing capacity, skills and education explain the lack of in-house expertise, the lack of time to devote to training, and the lack of training itself, which, according to questionnaire results, were the main human resource barriers to digitalisation and information modelling for planning.

Budget

In keeping with the theme that barriers to information modelling are all interrelated, cuts to planning authorities' budgets have made it difficult for departments to attract and retain talent, and invest the money and time in staff training. Furthermore, local authorities are in competition for talent both with each other and with private consultancies that offer greater salaries. Lean budgets also mean staff reductions, and less time and budget for training. As one local authority planning stakeholder put it, *"The problem is that there's no money for training, so people have been here a long time, and they've never had any training on anything other than excel."* Implementing information modelling for planning is going to require upskilling for planning departments, as is discussed further below, but without funding to support training, using new digital systems will be challenging.

Staffing capacity

Because of tight budgets, planning departments are often overburdened by their daily work. As one stakeholder noted about colleagues in the planning department, *"they're so busy, they've just got their heads down, and they're delivering their day jobs, and so the digitalisation of the planning service is just not something that they can do"*. Some stakeholders emphasised a need for data specialists in planning departments; however, most planning authorities will struggle to allocate the human resources to such a role. Scottish stakeholders reported that while previously some local councils had an entire team of GIS specialists located in planning departments, they have had to cut back and now must bid for time from GIS personnel that support the entire council.

Our research revealed that in spite of digitalisation efforts, there still are a number of planning processes that are done manually. For example, many authorities rely on on-site visits to audit development, which is time consuming. Planners also noted that a significant portion of their time is dedicated to administrative work, generated by aspects of digital planning processes. In particular, smaller authorities noted challenges with managing continuous updates to planning software such as Idox. This was part of the motivation for moving to a hosted solution for some councils, but since doing so, they now suffer from slower network speeds.

Integrating new digital ways of working or new collaborative relationships requires time, which is something many planners do not feel they have. Talking about digitalisation and a new shared planning service, one planner said, *"To implement something like that you'd have to have enough staff because there's no way you could cope with your day to day job as well as making sure this new system works. We can barely cope with our day-to-day jobs with our current level of staffing"*. This theme was repeated throughout interviews, emphasising a lack of staff and a lack of time

One of the anticipated uses for information modelling for planning is the ability to facilitate greater public engagement. The Scottish Government has specifically indicated a desire to engage a broader range of community members in the planning process. However, greater public participation will make further demands on planners' time, so any move to increase participation, whether through greater digitalisation or in person engagement, must be accompanied by a plan to release additional resource to planners.

Technical Skills

Implementing information modelling for planning would require upskilling in most planning departments. In contrast to what our overall questionnaire data demonstrated with regard to the use of 3D modelling, our case study interview data analysis indicated that most planning departments do not seem to frequently use 3D models. Some planning departments reported relying on developers to provide models to them, sometimes as flat PDF files. One local government respondent to the questionnaire reported that their Building Control department receives BIM files, but that most members of the department lack the skills required to interpret the model and that applicants submit files with unnecessary detail. Depending on how planning software evolves, information modelling for planning may require local authorities to have the skills (in addition to the software) to create and modify 3D BIM models. This will require further investment in training, which is covered in more depth later in this section.

Finally, planners may not be the only ones who will need to be comfortable navigating 3D models. Partner departments as well as the public may need to be confident when dealing with 3D models for planning, which points to the need for a very easy-to-operate system for interacting with the models.

Legal and procurement knowledge

While a lack of technical capacity can block BIM for planning, a lack of legal and procurement knowledge also represents a barrier. For example, as mentioned in the organisational and data-related barriers sections, when departments are unsure what data they can legally share, it hinders data exchange. As one local authority stakeholder reported*, "No one's entirely sure what they're allowed to do with what they've got. Which means that we're not using it in the right way. It's just sitting, dying somewhere, instead of being used and analysed and properly utilized. Because there's a fear that we might be breaking the law, basically"*. Therefore, planners involved with information modelling may need to have greater legal knowledge. In a similar vein, understanding around data ownership is lacking for some local authorities. Authorities have had negative experiences in which outside providers owned their data and they could not freely access it. In response, one stakeholder shared that some authorities have started trying to own the intellectual property associated with technology they use, which is different from owning the data and which technology partners cannot agree to. Better training for procurement officers on data ownership and the difference between data ownership and IP will be necessary to enable implementation of information modelling for the planning system.

Education and Upskilling

Presently, education represents a significant barrier to implementing information modelling for planning. Looking to the future, to educate the next generation of planners, universities will need to have teachers who can teach the right skills. Furthermore, students will have to overcome any psychological barriers they may have to learning additional software programs. Even though the job market does not yet demand BIM skills for planners, if information modelling is to serve the planning system, the need for BIM skills must become part of the narrative around planning. Currently most planners do not see information modelling as relevant to their work because BIM is seen as a tool for the AEC industry, not seen as a tool for planning, which can create a psychological barrier.

Barriers to upskilling for the current planning community represents a challenge for implementing information modelling for planning. Planning authorities do not have the budget, and personnel often do not have the time to attend trainings. When asked for their wish list, one main consideration mentioned by stakeholders was "time". Furthermore, some organisations reported that the needs of their departments were very specialised, and that there were not training bodies out there that would be able to cater to their employees specific interests. Finally, some stakeholders noted that the planning staff that is close to retirement are not interested in learning new digital tools.

Solihull, which has adopted BIM in the design team that sits as a part of their architecture team, has conducted BIM training for staff; however, the training was not aligned with when staff were able to start projects that use BIM, and so staff struggled to solidify what they learned before forgetting it. This emphasises the importance of timing training to be most effective.

Many planning courses in the UK have not taken up newer software developments in their teaching portfolio, yet. It will take years until teaching courses across the UK have incorporated BIM to an extent that employers can expect students of an accredited planning course to have acquired basic BIM skills. In this instance, universities would need money to buy software, which may pose a challenge as often departments compete with one another for funding. There are, however, some full and part-time BIM master courses available in the UK. This is of particular interest for people already in employment, as part of advanced vocational training. However, these offers are limited at this point in time, and may be attractive only to planners with a technology-driven approach.

4.5.5. Financial barriers

Financial constraints undergird or exacerbate most of the barriers already discussed in this analysis thus far. Respondents to the questionnaire indicated that the top financial barriers to implementing information modelling for planning are that the necessary trainings are expensive and that hiring the right personnel is expensive. Secondly, respondents indicated that information modelling is something that multiple departments would use, but that there in not enough procurement coordination to take it on. Thirdly, respondents indicated that information modelling software is expensive (Table 19).

Financial shortcomings present one of the most significant barriers to information modelling. As is the case with all of the barriers, financial barriers are closely related to other types of barriers, and financial support could often help overcome barriers in other categories.

Analysis of case studies and stakeholder interviews revealed two general types of financial barriers. One related to the pure financial needs involved with supporting digitalisation and information modelling for planning. However, some financial barriers were related, on a higher level, to financial models and procurement decisions.

Financial needs

Our analysis highlighted a number of financial constraints that hinder digitalisation and could block implementation of information modelling for planning. As was discussed in the human resource barriers section and underscored by questionnaire responses, there is limited budget for training personnel and for hiring personnel with the right digital skills. Authorities also have to consider the cost of data storage. Planning authorities had varying opinions about whether storage costs represented a significant burden, but they were in agreement that these costs represented a risk for local authorities. One planner noted that the council gets fined if the planning department exceeds their upload storage limit, and another highlighted concerns that storage providers could increase prices, putting local authorities in an untenable position. This underscores concerns about files sizes and level of detail for information modelling for planning, which were discussed the in data-related barriers section of this report. On a related note, local authorities highlighted concerns over where, geographically, their data is stored. Scottish local authorities are worried that they will have to pay to migrate their data over from service providers in England to the new system in Scotland that the government is developing. Other stakeholders indicated that they did not know where their data is stored, which could propose legal challenges, discussed further below.

Software and hardware expenses were also noted as barriers to digitalisation. Stakeholders noted that using BIM is expensive, but they are not able to charge additional fees when they use it. The cost of software for digitalisation efforts in general was noted as barrier. One Scottish council reported paying £8,000 per annum for a development planning platform, and expressed frustration that there did not seem to be better, cheaper, integrated options to fill their needs. Others pointed to the mounting costs of upgrades.

Some stakeholders pointed to regional differences in the financial barriers to digitalisation. In more populous areas that have traditionally received greater investment, it is more likely that modelling data already exists. However, in more rural areas, mapping and modelling data will have to be created from scratch, which poses a financial barrier to areas that may already find the costs of information modelling burdensome.

Table 19: Financial barriers to digitalisation and implementing Information Modelling

Challenge	%	Count
Information modelling software is expensive	13.98%	13
Software connectors are expensive	4.30%	4
We would have to upgrade our hardware	11.83%	11
We cannot afford the data storage costs associated	3.23%	3
The necessary trainings are expensive	17.20%	16
Hiring the right personnel is expensive	17.20%	16
Information modelling is something that multiple departments would use, but there is not enough procurement coordination to take it on board	16.13%	15
Unclear value proposition	6.45%	6
Other	3.23%	3
N/A - my organisation does not face financial barriers	3.23%	3
Unsure	3.23%	3
Total	**100%**	**93**

Source: own elaboration

Financial models and procurement decisions

Some of the financial barriers that our analysis revealed were related to the financial models required to support digitalisation and information modelling for planning. Stakeholders highlighted the need for a clear business case to support investment in information modelling. Specifically, stakeholders noted that at least part of the return on investment has to come quickly enough to motivate adoption of information modelling. Without a clear business case with a relatively short return on investment period, public leaders will struggle to allocate budget. This is also related to barriers mentioned previously. Budget decisions for local authorities are typically made by elected politicians, who have time-bound periods in office and must have a clear understanding of the value delivered by information modelling in order to support investments in it. Not only is the business case not always clear to the public sector, but the private sector also requires clarification: one developer highlighted the need for a business case, asking what the value-add is, in terms of time versus cost, for BIM adoption.

Stakeholders flagged some organisational strategies to reduce the costs of digital platforms, and highlighted pitfalls. Some authorities seek to create shared planning services motivated by a desire to share the cost of planning software. However, this strategy is not successful unless the authorities generally want to align their work practices. While entering into shared planning systems can deliver efficiencies, there are risks involved in joining up separate services. For example, South Cambridgeshire and the City of Cambridge have come together to offer a combined planning service. While this makes sense geographically, as the two areas are intimately related, it poses challenges because at present the two councils are controlled by different political parties with different agendas. This can make reaching agreement on policies, procurement decisions, and strategies difficult.

Finally systems that fund innovation for local authorities have not always successfully contributed to scaling solutions. Multiple stakeholders flagged the inadequacy of pilot projects in bringing about systematic change. Stakeholders noted that pilot projects were not sustainable, as there was no ongoing funding mechanism to support the changes or innovations they brought. Additionally, pilot projects may lack the ability to scale beyond the individual authority they support, as they may be specific to the needs and structures of one authority. The Ministry of Housing, Communities and Local Government has provided money for local council innovation through the Local Digital Fund. However, there is no clear path to scale the innovations this fund supports to extend beyond the authority that develops it. This is in keeping with the general observation that innovation for local governments does not scale easily due in part to the fragmented nature of the market. Our analysis also uncovered duplication in efforts, with the Scottish Government and several local councils in England all looking to produce similar technological solutions to support better public engagement. While having competing solutions will help produce good results, stronger coordination in funding and better plans to scale innovation would help reduce duplicative efforts to deliver greater benefit to more councils.

4.5.6. Legal barriers

Our analysis revealed a host of legal and potentially ethical barriers to implementing information modelling for planning. This section covers both the legal and the ethical concerns because the two are often interrelated, as law under consideration often exist to protect people's rights. Analysis of the questionnaire data revealed that the top four legal barriers according to stakeholders are that: (1) there is not enough guidance on how to comply with existent data management practices, laws and regulations; (2) GDPR; and a tie for (3) between respondents not knowing what they are legally allowed to use or share, and liability concerns (Table 20). Respondents also noted that there is a need for legislation around defaults, accuracy, liability, length of liability, who keeps and updates master models, and who owns the data (Table 20). This aligns directly with insights developed from stakeholder interview analysis. The sections below explore the potential legal and ethical barriers to digitalisation.

Table 20: Legal barriers to digitalisation and implementing Information Modelling

Challenge	%	Count
There is not enough guidance on how to comply with the numerous data management practices, laws and regulations	17.78%	16
GDPR	12.22%	11
I don't know what I am legally allowed to use or to share	10.00%	9
Liability concerns	10.00%	9
Getting legal approval is time-consuming	8.89%	8
Other departments or organisations will not share data with me because of legal constraints	8.89%	8
My data cannot be stored in another country	7.78%	7
I do not know where the data is stored (e.g. when using a hosted solution)	5.56%	5
Unsure	5.56%	5
Insurance	4.44%	4
My data cannot be stored by another organisation	3.33%	3
Other laws or regulations	3.33%	3
N/A - my organisation does not face legal barriers	2.22%	2
Other	0.00%	0
Total	**100%**	**90**

Source: own elaboration

Complex legal and regulatory environment

In keeping with the questionnaire results, one of the most prominent legal barriers to information modelling for planning is related to the difficulty of complying with data management laws and codes of practice. A stakeholder at Historic Environment Scotland (HES) shared with us a non-exhaustive list of all the legislation, statutes, codes of practices and policies that HES must follow with when using BIM to ensure compliance with information technology and information security requirements. To engage with BIM and data management practice effectively, HES has to comply with nearly 60 requirements (Table 21).

Table 21: Legislation, Statutes, Codes of Practice applicable for IT and Information Security Requirements at Historic Environment Scotland

Data Protection Act 1998	Environmental Information Regulations 2004
Freedom of Information Act 2004	Serious Organised Crime and Police Act 2005
Official Secrets Act 1989	Computer Misuse Act 1990
Freedom of Information (Scotland) Act 2005	Planning and Compulsory Purchase Act 2004
Privacy and Electronic Communications Regulations 2003	Re-use of Public Sector Information Regulations 2005
Public Records Acts 1958 and 1967	BS 1192-4 2014
ISO BS EN 19650-1 + 2 2019	BS ISO 55000 2014
PAS 1192-5:2015	Civil Contingencies Act 2004
Limitation Act 1980	Computer Misuse Act 1990
Copyright, Designs and Patents Act 1988	Planning Acts (various)
Counter-Terrorism and Security Act 2015	Police and Justice Act 2006
Data Protection Act 1998	Privacy and Electronic Communications Regulations 2003
Data Retention and Investigatory Powers Act 2014	Privacy and Electronic Communications (EC Directive Amendment) Regulations 2015
Digital Economy Act 2010	Public Records (Scotland) Act 2011
Electronic Communications Act 2000	Regulatory Powers (Scotland) Act 2000
Environmental Protection Act 1990	Scottish Commission for Human Rights Act 2006
Equality Act 2010	Terrorism Act 2006
Freedom of Information (Scotland) Act 2002	The Environmental Information (Scotland) Regulations 2004
Health Acts (various)	The EU Cookie Law
Human Rights Act 1998	Intellectual Property Act 2014
The Waste Electrical and Electronic Equipment Regulations 2013	The Workplace (Health, Safety and Welfare) Regulations 1992
Town and Country Planning Acts (various)	BS 7858 2012
BS ISO 15686-4 2014	BS ISO 29481-2 2012
BS ISO 55000 2014	BS ISO 55001 2014
BS ISO 55002 2014	PD ISO / TS 1291 2012
BS ISO / IEC 27001 2013	Intellectual Property Act 2014
The Waste Electrical and Electronic Equipment Regulations 2013	

Source: Eamon Gilson, BIM Manager, Conservation Directorate, Historic Environment Scotland

The complexity of the legal regulatory environment surrounding data management and handling practices represents a barrier to implementing information modelling for planning, particularly because planning is a public facing function and can deal with sensitive information. Data must be handled properly at multiple stages, from collection, to transmission, storage, access, and ultimate use. The challenges inherent in knowing how to remain in compliance with best practices while producing, using and sharing data create such barriers that some local authorities reported that they opt to not share data when possible, because of the legal hurdles they would have to clear. As discussed earlier, these legal restrictions and uncertainties prevent data sharing both between departments in the same organisation, and between organisations. The legal environment must make it easier for government departments to say yes to sharing data, if information modelling is to be successfully implemented for planning.

In a similar vein, planners shared the belief that Ordinance Survey data will be important in any 3D information modelling system for planning, but that at present it cannot be released publically. Government stakeholders that were using BIM also reported that their internal IT approval processes for working with BIM components slowed down their work, prompting them to design work-arounds. For example, one interviewee reported that the process to get approval from IT and to get the necessary components on his desktop could take between four weeks to six months. Finally, some governmental departments reported a need avoid storing any data on external servers, which made it difficult for them to find technology partners. These are hurdles to overcome in order for information modelling to be successful in the planning context.

Liability and insurance issues

Insurance and questions surrounding liability are another potential blocker to information modelling for planning. New models are made through the planning application and development life cycle, as new contractors enter into projects for insurance reasons and because contractors do not want to assume liability for another organisation’s work. This relates to the challenge mentioned earlier in the data related barriers section, that developers use multiple BIM models throughout the lifecycle of their projects, and if a BIM model exists at the planning application phase, it is not likely to be an accurate model of what is actually built. There must be a system to better support collaboration and to assign responsibility for model validity and integrity. This will be necessary to facilitate use of and build trust in any information modelling system for planning. Users must trust the systems in order to make further plans based on the system’s intelligence.

Data storage and sharing

Our research highlighted that many local authorities are using or are interested in using hosted solutions. However, most of the departments we spoke with were not sure where their data was being stored. Given regulations on data storage, it is important for local authorities to know where their data exists, particularly in a post-Brexit world, where storing data outside the UK may pose a legal issue. However, stakeholders also reported a conviction that amazon web service have a monopoly on the storage market and that it is difficult to know where their service are hosted.

Data sharing was covered in depth under the data-related barriers section of this report. Sometimes legal constraints can block attempts at data sharing and collaboration. For example, the councils of East Ayrshire and South Ayrshire have a combined roads authority called Ayrshire Roads Alliance. Roads Alliance employees are East Ayrshire employees technically, and this means that due to data governance requirements they cannot access South Ayrshire’s systems to view drawings, and other crucial information for their jobs.

Data ethics

While some information about the built environment may not be sensitive, it may be that moving forward more sensitive information gets incorporates into planning information modelling. As is covered in more detail in the sections below, there are social responsibility and data ethics issues inherent in questions surrounding what data is collected and how it is shared.

There are different types of ethical concerns depending on the data in question. For example, if information modelling for planning relies on cameras or involves facial recognition, the system will pose an ethical and potentially legal challenge, centred on how to ensure citizens’ right to privacy.

Local authorities will also have to be careful of what technology companies they choose as partners. For example, authorities voiced a desire to have access to the types of data that Google has, but expressed concern that Google uses its data in ways that would not be acceptable for an accountable public body. Local authorities also cited concerns about monetisation of public data, and how that might impact on the public realm. The way that the planning information modelling system responds to these concerns will be crucial not only for its ethical integrity, but because it will be a determinant of whether the public feels comfortable and trusts the new system. Local authorities will have to find the right balance between protecting privacy and making data open source and available.

Stakeholders in Bristol are working on smart house concepts that could feed information about when inhabitants use a stove, or use heating, or even lay down in bed. This type of information is incredibly sensitive, and there must be complete and well-informed consent, if people are to live in smart houses that feed their movements back to the government. When approaching questions of consent, local authorities must be attuned to power dynamics and levels of understanding. This is of particular concern because some of the envisioned inhabitants of smart houses are elderly people and people living in poverty, who may have less exposure to conversations about personal data management and privacy. These are key questions to address when considering what types of data are necessary and appropriate for a planning information model system.

4.6. Overcoming barriers to digitalisation and information modelling for planning

As we argued throughout this report, barriers to information modelling and digitalisation are interrelated. Consequently, any approach to overcoming these barriers must be multipronged, tackling multiple barriers at once. Pouring resource into addressing one category of barrier may be necessary, but not sufficient to overcome barriers. Similarly, because of the interrelation of barriers, potential solutions will often help on more than one front. We have also made the point that the barriers to information modelling are the same barriers that will challenge almost any effort towards digitalisation. Consequently, overcoming these barriers represents an important step in actualising the potential that the digital revolution brings to the public sector.

The analysis below is not meant to be exhaustive. Given the interrelated nature of barriers, elucidating a cohesive strategy to overcome the barriers will require further research, looking at efficacy and prioritising options. However, a preliminary analysis of our data reveals five important areas for concentration, to pave the way for information modelling in planning: collaboration, leadership, investment and business case, innovation and strategic planning, and privacy (Table 22).

Table 22: Overcoming barriers to information modelling for planning

Collaboration	Leadership	Business case & investment	Innovation & strategic planning	Privacy
Collaborate to enable digitalisation	Provide guidance	Build a clear business case	Develop easy-to-use technology	Engage citizens
Digitalise to enable collaboration	Build momentum	Invest in human resources	Integrating BIM and GIS	Develop a socially responsible paradigm for collecting and sharing data
Enable collaboration between planning-relevant departments	Set organisational structures to facilitate good data use and management practices	Support enabling financial investments	Retrofit	Revisit privacy strategies
		Invest in good data resources	Bring together smart city and local planning	
			Reinvigorate strategic planning	
			Outsource the creation of a CIM by facilitating the collection of information models from applicants	

Source: own elaboration

4.6.1. Collaboration

Our case studies showed that when collaborative systems were in place, the road to digitalisation was easier, and when systems did not facilitate collaboration, digitalisation was challenging. Enabling collaboration is a powerful way to overcome multiple barriers to digitalisation, as it can help address barriers across all multiple categories of barrier. For example, it helps lessen the negative impacts of governmental fragmentation; it helps break down data silos and facilitates standardised data management practices; and it can help align technology purchase decisions, which can in turn facilitate data sharing.

Collaboration and joined-up ways of working

Our research showed that collaboration and joined-ways of working can enable digitalisation, and conversely, digitalisation can enable collaboration and joined-up ways of working. As mentioned previously, collaboration is important in strategic planning, and becomes more important as planning begins to use digital tools more intensively. For example, transportation, air quality, and energy are all interrelated concerns for the planning system: electric options for public transportation may help improve air quality, but implementing electrification requires an understanding of where energy capacity exists, and how much. Bringing this information together requires collaboration between within departments, and sometimes across organisations.

An area where we saw collaboration acting to facilitate digitalisation was with regards to planning and Building Standards. In Scotland, some local authorities use data collected through Building Standards to inform planners about building starts, and help planners keep track of what is actually being built. It may also be that Building Standards is an appropriate place to collect BIM models to inform a planning information system. As was mentioned previously, during the planning phase most developers do not yet have accurate BIM models, but by the time they start construction, they likely will have models. This could help outsource the creation of a CIM. The need for collaboration both to support digitalisation and to enable effective, sustainable planning was a strong theme throughout the stakeholder interviews.

Collaboration enables digitalisation

Our interviews pointed to the important role that collaboration, both vertically and horizontally across organisational hierarchies, plays in enabling effective digitalisation. For example, the Scottish Government recognised that if they use a digital platform to enhance public participation, this will create extra work for local authorities, and so the Scottish Government is committed to working with authorities to ensure they have the resources they need to handle the potential uptick in participation. Absent this type of support, digitalisation could lead to administrative burden that hampers rather than helps the efficacy and quality of public participation. This collaboration between higher and lower levels of government helps ensure that digital initiatives in the planning system are sustainable and effective. Horizontally, our research flagged the importance of collaboration across local authorities, which enhances efficiency by highlighting best practices and minimising duplicate efforts.

Collaboration enables digitalisation, and can enable information modelling for planning because information modelling for planning requires data input from multiple sectors. As our Bristol case study illustrated, digitalised collaboration can yield unexpected benefits. For example, Bristol co-located its Traffic Control Centre, Community Safety (CCTV) Control Room, and Emergency Control Centre into one operations centre, with a goal to manage better the city's traffic network. In addition to traffic benefits, however, the city was also able to combine CCTV and transport data to find missing persons.

Collaboration also promoted buy-in for planning exercises. For example, Bristol took a collaborative approach to creating its One City Plan, involving public, private, voluntary and third sector partners in the visioning and planning exercise. While the One City Plan is not a local development plan, it is a strategic document outlining the city's goals for the next 30 years and its delivery will require coordination from the planning department. Stakeholders in Bristol reported that they believe the collaborative planning process has led to stronger support for the One City Plan and greater collaboration between disparate sectors across the city. As mentioned above, this type of cross-sectoral collaboration is important for enabling information modelling in planning.

Finally, our research highlighted the importance of collaboration between departments and organisations for standard setting, so in the future multiple sectors will be able to rely on the same information systems.

Digitalisation enables collaboration

Our research pointed to how digitalisation can enable collaboration and joined-up ways of working. The Highland Council, for example, adopted the same software platforms across several interrelated but separate systems and departments, including their corporate gazetteer, building standards, planning enforcement, contaminated land, and developer contributions. Data from these separate areas is available on one digitalised system, which enables collaboration and greater value add for those who use the system. Information from the corporate gazetteer links planning applications with building standards, which are also then tied to road construction consents. Building completions data is used to notify developer contributions officers to invoice developers. The building completions data is also used for housing land audits. While feeding data from building standards into the planning system may seem like an obvious move, previous research has shown that often local authorities will manually count building completions (Future Cities Catapult, 2017), which is time consuming for already time-poor planning departments. As this illustrates, digitalisation can unlock greater collaboration and better use of resources for planning departments.

Collaboration between planning-relevant departments

Our case studies, and particularly the Scottish case study, highlighted the need for and benefits of cross-departmental collaboration in planning. As was argued in the barriers section, without information from, for example, those responsible for education and health services, planners cannot accurately create implementable visions for the futures of their communities. This is presently a hindrance for strategic planning, and will become an impediment to information modelling for planning in the future, as good modelling requires good data. Therefore, to overcome barriers, systems must be in place to create data flows and collaboration between planning and adjacent sectors.

Further benefits of joined-up ways of working

As was noted throughout the barriers analysis, many barriers stem from organisational fragmentation. With greater collaboration, issues around data standards and data sharing will be easier to resolve. Joined up approaches to procurement can help to address technological and financial barriers. It can help overcome the market failures described earlier in this report, related to a fragmented and difficult-to-navigate marketspace. Joined-up approaches to human resource barriers can help training roll-out and facilitate the sharing of best practices. In this way, enabling collaboration can help address each category of barrier.

4.6.2. Leadership

Leadership is necessary to overcome barriers to information modelling for planning. This is true in the literal sense: as was argued earlier in this report and has been argued elsewhere, digital champions are important in supporting digitalisation efforts. However, leadership is also needed in a broader sense of the word as well, from the government, for example, to create a facilitating environment for information modelling.

Guidance

Guidance is needed on several fronts to make information possible in the planning context. There is need for thought leadership and action around what data is necessary for strategic planning and planning information systems. This points to a need for further research to establish exactly what types of data are most relevant, and from where this data can be collected. There is also need for leadership in figuring out and establishing what the appropriate level of detail is for a planning information model, and creating standards around how data is recorded and used. There is need for simplified, easy-to-follow guidance around the best sharing practices, and how to collect, use and share data while remaining compliant with data privacy laws and regulations.

These are areas that need further exploration, and then strong leadership by government and/or the planning sector to produce and disseminate best practices and guidance.

Building momentum

Multiple stakeholders noted that for information modelling to take off in the planning sector, there will need to be a catalyst that plays a role similar to the one that the BIM mandate played in the construction sector. Something has to focus the planning community's attention on information modelling, and incentivise its uptake.

Organisational leadership

Organisations can take a leading role in addressing the barriers to information modelling by setting up organisational structures that facilitate good data use and management practices. In our case studies, we came across three examples of organisational structures that supported collaborative data-sharing. Bristol has one corporate technology division that oversees technology and data management for the whole city council. This ensured that all departments had support and worked with uniform data. This can also help with data upkeep and cleaning as it makes it clear whose responsibility data management is. We also heard from stakeholders that an effective approach would be to have each team or department have a data specialist on staff, although we did not see examples of this in action. Finally, we noted that organisations with devolved relationships with the government seemed to have strong data management practices and seemed to be on the leading edge with digitalisation and information modelling. Examples include Historic Environment Scotland, Scottish Futures Trust, and Solihull Metropolitan Borough Council's Building Design Group. Whether the arm's length relationship between these organisations and government is a coincidence or a cause of their innovative approaches to information modelling is unclear but merits further exploration.

4.6.3. Business case and investment

Building a clear business case

As stated earlier, the business case for planning information modelling must be clear if uptake is to be widespread across UK local authorities. This includes a realistic articulation of use cases, costs and benefits. A clear business case is crucial, as this is what political and administrative leaders need in order to marshal resources behind an initiative. A business case can also help structure the data requirements for planning information modelling, as it will help determine what types of data are useful and what types of data are not. Finally, a clear business case can help determine the appropriate level of detail for planning information modelling, striking the balance between the drive to have more data, and cost-effective, privacy-conscious data management. A sound business case makes the need for investment clear, which is another necessary focus area for overcoming barriers to information modelling, and is covered in the section below.

Investment

As argued above, financial barriers contribute to creating human resource, technological and data-related barriers. Therefore, overcoming these barriers will require investment on multiple fronts, namely, investment in human resources, investment in technology and data systems, and organisational investments in new structures and processes. Strategies that dedicate resources in these areas will help overcome barriers to information modelling.

Investment in human resources

Planning smart cities requires smart planners. For information modelling to be useful, there must be investment in training and development for planners, so they can confidently and effectively navigate not only data flows, but also the legal landscape surrounding data use. This is not to say that every planner needs to be a data scientist and a lawyer; rather information modelling software for planners must be developed to be user friendly, and steps must be taken to ensure that the legal requirements of data sharing are comprehensible. However, a certain level of complexity with data use, both in a technical and legal sense, is unavoidable. Therefore, appropriate investment in personnel training is necessary. Investment in human resources is not just about paying for the right trainings, however. As the Bristol case study makes clear, providing planners with the time to investigate software uses freely can be as effective if not more so than scheduling formal trainings. Furthermore, as experiences from Solihull indicate, training must be timed carefully to ensure that trainees are able to put their skills to use quickly enough to solidify their knowledge.

Financial resources

As was emphasised throughout the barriers analysis, funding is required throughout digitalisation efforts to cover hardware, software, data storage and training costs. Simply put, even if digitalisation and information modelling provide long-term benefits, without the upfront investment, no change will be visible.

However, freeing up funds to invest in information modelling will require the construction of a solid business case, showing the benefits, both short and long-term, of the investment. The Scottish Futures Trust created an online tool that supports users in figuring out the benefits of BIM in building processes; a similar such tool may be useful in overcoming financial barriers to information modelling.

Given the financial constraints that local authorities face, considering new procurement strategies may be useful. Our case studies revealed that sometimes, local authorities enter into joint planning relationships to bring down software costs. Local authorities could take this method further to form purchasing consortia, or software could be purchased off framework contracts negotiated at higher levels with support of local authorities.

Additionally, if local authorities can work to combine their purchasing power, it may improve the overall innovation environment for service providers, as this would mean that the would-be innovators discussed in the barriers section would have a less fragment market to deal with, and this may help solve some failures in the public sector software services market.

Data resources

Information modelling for planning will rely on the availability of the right kinds of quality data. Therefore, means to standardise, control the quality of, and share data will be fundamentally important. Our Bristol case study shows that organisational structures that bring together diverse data flows, like the city's operations centre, or that centralise data management power in a corporate function, like the council's corporate GIS technology team, can help overcome barriers to digitalisation. Bristol planners noted that having access to council tax data, building control records for starts on sites, and land and property gazetteer information helped them conserve another key resource—time. Accessing this data helped them avoid on-site visits, which saved them time. In this way, investing in good data resource management can free up time and cost savings for local authorities.

4.6.4. Innovation and strategic planning

Innovation, both in terms of the technology employed, and also how the planning system operates, will be key to enabling information modelling for planning, and to facilitating public benefit from data use. Below we outline how technological and planning innovation can enable a facilitating environment for information modelling in planning to benefit the public.

The right technology

Technology solutions are needed to help overcome barriers to information modelling in planning. Planners note that there are no planning-specific information modelling tools, which makes using information modelling in planning difficult. Furthermore, our research showed that many local authorities struggle with their current digital systems. Adding another complicated digital tool to the mix will not be welcome and will not facilitate better outcomes in planning. Any planning information modelling tool must be developed to be easy-to-use and intuitive. There may be planning stakeholders from less technical areas that need to use the tool, or it may be that the tool becomes public facing, and so the general public must be able to interact with parts of it. An ideal digital tool for planning information modelling would be as simple to navigate as google maps, as one planning stakeholder put it.

As alluded to previously, the appropriate level of detail for planning information modelling must be established—something detailed enough to provide insight, but not so data-heavy that computer systems struggle. Technology musts evolve to support this. We also noted tension between the drive to enable customisation for local authorities, and the need for standardisation. It will be necessary to strike a balance between these two needs, particularly for regional and national initiatives, to ensure that technology meets the individual needs of users, while also facilitating standardisation to enable regional and national system-wide collaboration.

Integrating BIM and GIS

Currently, much planning work is done in GIS. Integration tools that enable GIS and BIM functionalities will be useful in this space. Indeed, the market is heading in this direction, with leading BIM and GIS software providers, Autodesk and Esri, announcing a collaboration in 2017 ("Autodesk and Esri Partnering to Advance Infrastructure Planning and Design," 2018). Further progress in this field will bring the worlds of planners closer to the worlds of the AEC industries, and facilitate feed-through of information from construction to planning. This is a necessary step in overcoming barriers to information modelling for planning.

Retrofit

Lastly, overcoming barriers to information modelling will require a solution for cost-effective information modelling retrofit, so to speak. There will need to be an efficient way to collect data from already existing assets that is necessary for a planning information system, and to feed it into models. Stakeholders indicated that investing in mapping areas outside the major urban hubs will be more challenging, as the base modelling for these areas may not yet exist.

Bring together smart city planning and local planning

Innovation in technology is necessary, but not sufficient for delivering value from information modelling in planning. If planning is not positioned to play a strategic role by agglomerating useful data flows and putting insights to use to enable more efficient resource allocation, then technical innovation will not deliver its promised value.

In our analysis, we noted that planning was often considered separate from smart city initiatives. When we contacted local governments to talk about building information modelling, we were often directed away from planning departments and on to different business units that were focused specifically on technology or smart city strategies. Smart cities are supposed to be the cities of our future, and building smart cities requires smart planning. Therefore, it follows logically that there needs to be more intentional overlap between the parts of local authorities focused on technology and smart cities, and those focused on planning for the future. Local planning must link with smart city planning to ensure that technologically enabled visions for the future, particularly if smart city strategists envision large changes in transportation (e.g. changes in parking needs or vehicular traffic), are aligned with local plans.

Reinvigorate strategic planning

The current priorities in the planning system may not be conducive to supporting information modelling for planning. Planning as a tick-box exercise that mainly evaluates applications against a set of criteria has no need for information modelling. If local authorities are measured on how quickly they can tick the boxes, so to speak, planning will benefit from further automation perhaps, but not necessarily from a system as involved as information modelling. The role of planning must be reinvigorated to ensure it has a strategic function. As has been argued consistently in this report, this requires meaningful and timely contribution from different departments in local government to local plans. To make a business case for planning information modelling, planning must be free to play a truly strategic role in setting and delivering on priorities and goals for the future of communities.

Outsource the creation of a CIM by facilitating the collection of information models from applicants

As was explained earlier, most applicants will not have a realistic BIM model when they submit their planning application, because the risk the application might be rejected makes investing in the model before permission is granted unappealing. To operate efficiently, the planning system must figure out how and at what stage in the planning process it makes sense to collect information models from applicants to feed into the system. As mentioned above, it may be that BIM models are best collected by Building Standards/Control, either when seeking permission for work to be done or when seeking completion certificates.

4.6.5. Privacy

We have argued throughout this report that building the right infrastructure to facilitate data use, while ensuring citizens' right to privacy, is of primary importance in any information modelling project. One of the core questions we probed was how to be a socially responsible local government or city when using information modelling.

Engage citizens

If planning information modelling is going to become a beneficial tool in the planning system, then it must be designed to facilitate and support public participation. This has a host of ramification, from how large files are, to how interfaces are designed, to what kinds of data can be shared and incorporated into the models. Citizen engagement must be forefront in the minds of stakeholders the tools and systems that support planning information modelling are developed, if the system is to have the trust and buy-in from the public. One of the primary goals articulate across planning literature, as it relates to smart city development, is the desire to effectively facilitate citizen engagement and participation in the planning process. Digitalisation and information modelling, as is argued above, have the potential to facilitate increased participation; however, developing a trustworthy data management system will be important for engendering citizen trust and buy-in to the system.

Develop a socially responsible paradigm for collecting and sharing data from the built environment

Throughout our project, we explored approaches to data handling. Currently, the most broadly used approach to data sharing and management appears to be the one prevalent in the Internet of Things (IoT). In this paradigm, service providers often ask users to agree to have their data used in the ways a service provider would like, or to not use the service. Users typically do not have the time or patience to wade through legal documents, and so face either accepting the terms or opting out of using the system. Take the company Nest for example. Owned by Google's parent, Alphabet Inc., Nest offers a variety of smart devices that monitor the home, as well as the homeowner. It makes thermostats that learn their owners' behaviours, carbon monoxide and smoke alarms, cameras, video doorbells, and home monitoring systems that feature facial recognition. All of its devices are designed to share information with each other and with other connected products, like cars, ovens, fitness trackers and beds. Allowing Nest to access your data means allowing a host of third party partners access as well (Zuboff, 2019b). A 2016 analysis conducted at the University of London found that someone who purchases a Nest Thermostat would need to read close to 1,000 legal documents to understand with whom and how her data is shared and used (Noto La Diega and Walden, 2016). Even if a proactive consumer had the time and legal knowledge to undertake reading all the documents, she would be hard-pressed to do anything about it if she did not agree with some of the stipulations. The Nest Terms of Service indicate that if a user does not accept, the thermostat's functionality and security would be compromised, leading to possible consequences ranging from frozen pipes, to failed smoke alarms. In essence, without agreeing to share data with an untold number of third parties, the Nest Thermostat is useless.

It may be reasonable to suggest that individuals who do not want to share their data with Nest's partners should simply not purchase a Nest. What happens, however, when the thing collecting and sharing your data is not a website ones visited or something ones purchased, but instead the street one walks on? Sidewalk Labs, another Alphabet Inc. company, is planning the development of a 12-acre swath of

Toronto's waterfront, called Quayside, where sensors will be used ubiquitously (Woyke, 2019). Though Sidewalk Lab's business model will likely focus on licensing the technology it creates than selling the data it collects, last year the company refused to unilaterally ban personal data collection, saying that it could not do so because it did not have authority over all the private-sector entities that may one day come to operate in Quayside (Fussell, 2018).

This agree or opt out paradigm is not appropriate for public spaces, and if information modelling uptake spreads and becomes more sophisticated in the built environment, local authorities must create frameworks that guarantee citizens a new right to the city. Cities need a clear understanding of how to collect and share data without risking people's privacy, and citizens need real choices about how, when and with whom their data is shared. It is crucially important that, as cities become smarter, they do not follow the IoT paradigm of share data or be excluded. Because the digital revolution is still relatively new in the realm of the built environment, frameworks and norms are still fluid. The Gemini Principles, referenced in our literature review, offer insights into a strong framework for approaching data privacy in the built environment (Bolton et al., 2018). It is important that local and national government develop the concepts and frameworks that ensure citizens' rights are protected. In discussions around smart cities, multiple ideas about "smart citizens" and "netizens" are developing. It will be necessary to stretch these concepts to include plans for citizen education to ensure citizens understand their rights and how their data is collected, shared, and used. This equips citizens with the knowledge they need to decide how they are willing to share their data to participate in the process of making cities smarter. However, it can also complicate smart city development and information modelling by making it harder for cities to use big data generated by citizens.

Revisiting privacy

In the Literature Review section, we highlighted that the research pointed out the numerous ways that academic literature discusses privacy, and we established the legal right to digital privacy. We also noted the challenge of data production and use in the hands of private and public stakeholders, as well as the opportunity for cyberattacks.

The importance of privacy considerations and the value of being a state or city that takes a responsible attitude towards data production, use and security cannot be underestimated. On the contrary, the very functioning of democratic states and societies depends on conscious development in dealing with new technologies.

Our empirical analysis and the case studies also alluded to data-related challenges on the one hand, and to a challenge for local authorities in dealing with existing sets of standards and rights. Interestingly, currently, due an already complex legal setting local authority stakeholders are uncertain about how to ethically and legally use and share data, which prevents stakeholders in local authorities from furthering their digital journey.

Against this background, a major motivation of this report is to foster a debate and a process in the UK to address data security, data ethics and challenges through privacy strategies. Barcelona has been an example where technological sovereignty has been discussed (Calzada 2018a 2018b) through the Barcelona Initiative for Technological Sovereignty (BITS).

Privacy strategies may be developed through, for example, a technology-driven approach of respondent, user and owner privacy, as suggested by Martinez-Balleste et al. (2013). This may, for example, help in managing a smart city with numerous techniques such as smart parking services, electric car recharging or smart building control of presence.

Local authorities may also want take on board a taxonomy of privacy breaches and harms, and relate the existing legislation to these, where Kitchins' approach (2016b) may provide useful input to differentiate between different forms of privacy:

- identity privacy (to protect personal and confidential data);
- bodily privacy (to protect the integrity of the physical person);
- territorial privacy (to protect personal space, objects and property);
- locational and movement privacy (to protect against the tracking of spatial behaviour);
- communications privacy (to protect against the surveillance of conversations and
- correspondence); and
- transactions privacy (to protect against monitoring of queries/searches, purchases, and other exchanges) (Kitchin, 2016b, p. 5).

Smart cities and BIM necessarily touch upon all these forms of privacy. The Gemini Principles as introduced in section 2.3.2 show that BIM and UK stakeholders subscribe strongly to privacy as a basic human right, which is enshrined in national and supra-national laws. In the UK cultural and legal context, privacy and security are of relevance. Considering different forms of privacy may help to design software and processes that live up to the demands of a democratic state in the 21st technology century.

4.6.6. Exploring recommendations to Government: stakeholder views

As a first step towards developing recommendations to government on how to overcome barriers to digitalisation and information modelling in planning, we prompted stakeholders during interviews and in the questionnaire to articulate the ways in which government could best support them. Stakeholders' views on what government can do to support the uptake of information modelling in planning were diverse, and there was no clear consensus on the one right way to support information modelling uptake. As Table 23 below illustrates, the ideas that received the most backing were supporting greater R&D, and mandating digitalisation. Additionally, stakeholders were interested in subsidies, requirements for information exchange between local authorities and developers, and pilot projects. Support was spread out for other initiatives, ranging from providing additional planning guidance, to offering technology training to citizens. The wide array of opinions on how government can support information modelling uptake is congruent with our finding that the barriers to information modelling uptake are diverse and interlinked. Consequently, action on multiple fronts simultaneously will be necessary to overcome barriers.

Further research is necessary to delve deeper, identifying the simplest and most effective ways for government to work to enable local authorities to digitalise and adopt information modelling for planning. However, government clearly has a role to play in freeing up human and financial resources, in supporting less fragmented governance structures, and in creating the momentum to drive progress in information modelling in planning. While not meant to be exhaustive or prescriptive, the focus areas enumerated in this section on overcoming barriers provides a good starting point for a deeper inquiry into the subject.

Table 23: What governmental and other organisations should do to support information modelling implementation for planning

Action	**%**	**Count**
Support R&D	9.14%	16
Mandate digitalisation	8.57%	15
Provide subsidies	7.43%	13
Require developers to provide local authorities with data and models	6.86%	12
Support and deliver pilot projects	6.29%	11
Support more collaboration and joined-up ways of working	5.71%	10
Offer framework contracts for procurement	4.57%	8
Provide planning guidance	4.57%	8
Create standards	4.57%	8
Amend national planning frameworks	4.00%	7
Offer guidance for technology providers	4.00%	7
Encourage machine-readable planning documents	4.00%	7
Provide clear legal guidance about data sharing	3.43%	6
Make ordinance survey data easier to share	3.43%	6
Provide more standardised software packages with standardised fields to enable cross-council collaboration	2.86%	5
Provide more integrated, joined-up planning management software	2.29%	4
Provide simplified legal guidance on how to share data	2.29%	4
Provide technology training for citizens	2.29%	4
Simplify local government structures	2.29%	4
Provide regulation for how data from citizens and the built environment can and cannot be commodified	2.29%	4
Create a government innovation centre	2.29%	4
Provide technology training for public employees	2.29%	4
Offer central investment in national services and tools for planning	1.71%	3
Work to address technology monopolies	1.14%	2
Support better connectivity for citizens	0.57%	1
Other	0.57%	1
Unsure	0.57%	1
Produce a coherent new planning bill	0.00%	0
Total	**100%**	**175**

Source: own elaboration

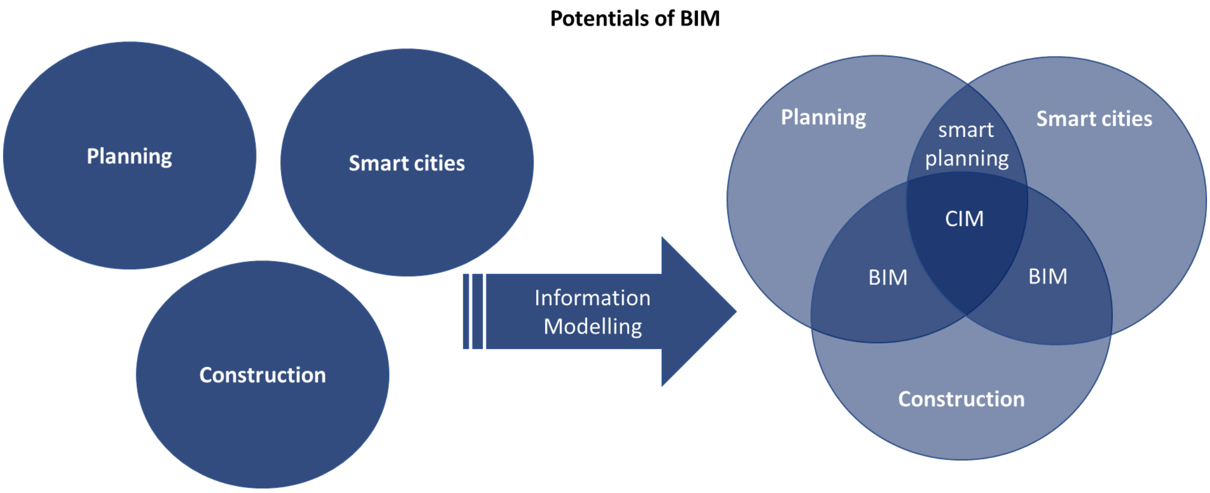
Conclusions

4.7. Delivering value through planning, smart cities and construction

This research project probed the relationship between information modelling, and in particular BIM, and the UK planning system, to develop an understanding of how information modelling might enable planning. The research investigated the barriers to implementing information modelling for planning. In doing so, the project focused on identifying what planning stakeholders might need from any software that aims to enable integrated smart city planning and management, or deliver public benefit from integrating and analysing data flows. Our research also explored the role of local authorities as data producers, managers and users, and how this affects the relationship between citizens, public authorities and the private sector, creating a need for a new privacy paradigm to undergird the coming decades of digitalisation.

Our research supports our findings from studying the literature, showing that at present conversations around planning, smart cities, and construction often take place in silos, separate from one another. However, in terms of tools, goals, and operational areas, these three fields have natural potential overlaps. Bringing these three areas of consideration into closer relation can help deliver the benefits sought in smart city strategies and from digital twins, incorporating real-time data flows to deliver efficiency and improved decision-making. From a digital tools perspective, combining the advantages of Geographic Information Systems (GIS) with the advantages of the 3D visualisations of CAD programmes can help bridge the gap between fields, enabling a new era of planning and urban management. (Figure 34).

Figure 34



Source: own elaboration

Our analysis shows that at present, the fields of planning, smart cities, and construction are still distinct. Information modelling has the potential to bring these fields closer together, and in doing so deliver some of the benefits that aspiring smart cities seek. Information modelling can be a means to enable smart city management and planning.

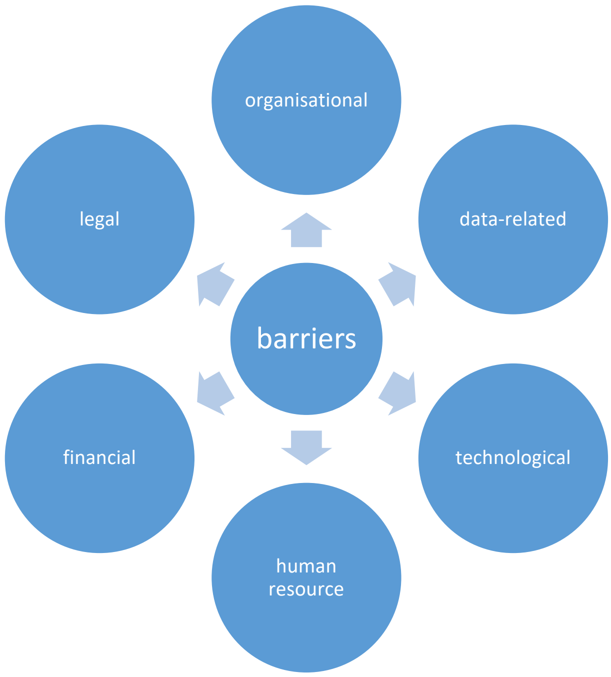
However, for information modelling to enable smart city management and planning, we argue that two issues in planning must be addressed. Enabling smart planning for smart cities will require bringing local planning into closer contact with smart city strategists and technology in general. When we contacted local authorities to discuss the future of planning and digital tools for planning, we were often referred to individuals outside of the planning department, highlighting the silos that exist in some local governments between the planning departments, and parts of the government that deal with digitalisation and smart city strategies. This division should be reduced to enable digitalisation in planning, and to set the planning system up to help deliver on smart city agendas.

Secondly, in speaking with local planners, we discovered that planners at times struggle to fulfil the strategic functions of planning, and instead spent much of their engaging in what was described as tick-box exercises. This was due to a host of factors, ranging from insufficient data from collaborating departments, to time shortages, to the design of the planning system itself. For information modelling in planning to deliver real benefit to the public, planning must be empowered to play a strategic role, bringing together diverse data flows for high-impact decision-making. Overcoming barriers to information modelling in planning is, in itself, not enough to deliver public benefit. Planning must be positioned to aggregate, process and action on the insight brought forward by information modelling to make it a worthwhile investment.

4.8. Main findings

Our research showed that local authorities are not close to adopting BIM, and even farther from incorporating CIM. Discussions with stakeholders revealed an eagerness to implement information modelling, but it appears that CIM, and the centre of the Venn diagram above, may still be a ways off. Our research identified the barriers to information modelling that stakeholders in the built environment face. In general, barriers fell into one of six main categories: organisational, data-related, technological, human resource, financial and legal barriers (Figure 35).

Figure 35: Barriers to digitalization and the use of BIM



Source: own elaboration

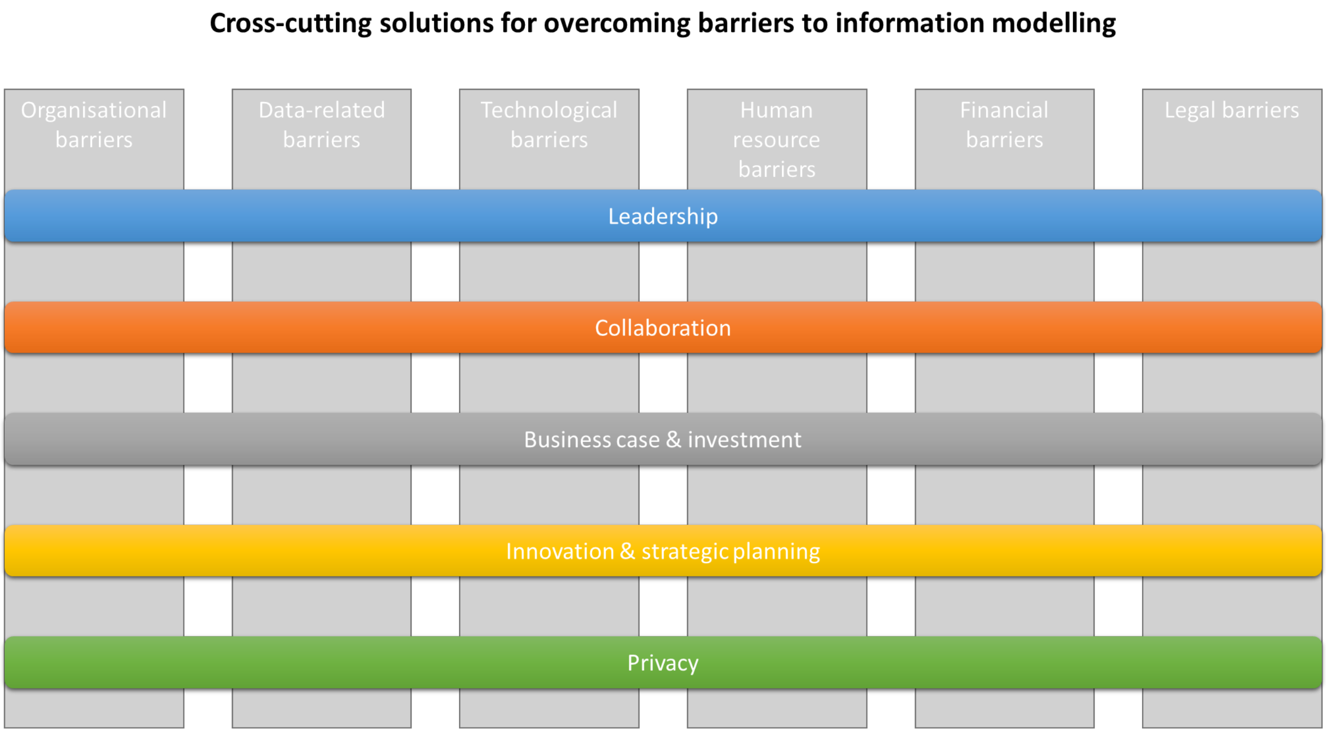
Studying these barriers revealed two key insights:

1. Barriers to information modelling are, almost without exception, barriers to digitalisation in general for local authorities and the built environment. This means that to reap the benefits of any major digitalisation endeavour, local authorities and their allies will have to contend with these barriers. Conversely, it also means that overcoming these barriers has the potential to deliver value beyond just what information modelling can bring.

2. Barriers to digitalisation and information modelling are closely interlinked. For example, financial barriers can prevent training or hiring personnel, creating human resource barriers, which then can lead to poor data management, which creates data-related challenges. One can map out causal chains starting with a barrier in any one of the six categories. This has implications for the approach to overcoming these barriers: focusing on one barrier type is necessary, but not sufficient for overcoming the barriers to information modelling in planning. A prioritised and coordinated approach will be necessary.

Our analysis also highlighted five areas for concentration to develop strategies for overcoming barriers to information modelling: collaboration, leadership, business case and investment, innovation and strategic planning, and privacy (Figure 36).

Figure 36



Source: own elaboration

As Figure 36 above illustrates, the focus areas identified for overcoming barriers to information modelling in planning are cross-cutting, and can help remove obstacles in multiple barrier categories. For example, having a sound business case behind information modelling will help with organisational barriers, as it will provide decision-makers with the rationale for marshalling support behind digitalisation initiatives. That in turn will help to address financial and human resource barriers, as leaders can make the financial case for allotting funding to large capital investments as well as hiring and training personnel. The business case can also help to focus information modelling for planning, addressing data-related barriers by helping to define the types and appropriate level of detail for data in planning information modelling. Having a strong business case and investment can contribute to creating a robust environment for innovation, which will help overcome technological barriers. Finally, articulating a sound business case can help set the parameters for the appropriate uses of data, which will help make clear what data must be shared, and what data is unnecessary. With this clarity, lawmakers can focus on creating systems that enable sharing only data necessary for achieving the aims of planning information modelling.

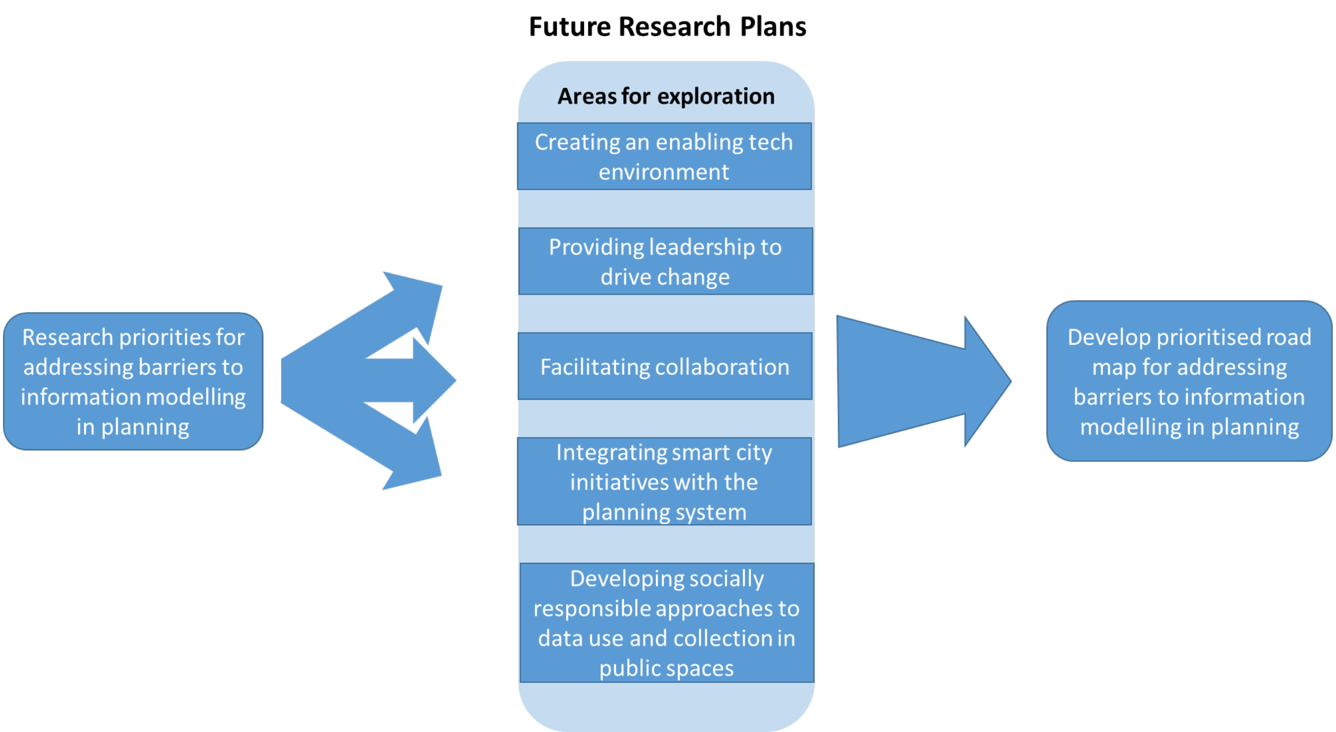
As the built environment becomes ever-more digitalised, questions around who owns data, who can access data, and who can profit from data become more and more pressing. Cities like Barcelona and Amsterdam may provide interesting case studies for understanding contemporary approaches to democratic data management and fair value-share for data use. However, no established norms exist yet in this area. As mentioned earlier, the Gemini Principles may serve as a good starting point for developing an approach to data management (Bolton et al., 2018). However, more specific management processes will be necessary to guide both the public and private sectors, and to inspire trust for the public at large. We argue that privacy considerations should be paramount in designing the ways in which data is collected and stored. The paradigm common for the IoT, which asks people to share data or opt out from a service, is not appropriate for public spaces, as it may result in restricting residents' ability or desire to engage with public spaces. Therefore, developing a socially responsible framework for local governments to use when collecting and using data from the built environment will be crucial for enabling a sound system to support planning information modelling, and other forms of digitalisation. In developing a new model, principles from Green's 'smart enough' approach (2019), may be useful for directing the UK's next steps in this area.

4.9. Developing recommendations and future research

As is often the case, our research revealed just as many questions as it answered. In this instance, we uncovered barriers for digitalisation and information modelling, which then raised a host of new questions around the best practical approach for overcoming these barriers. Therefore, this project represents a starting point for further research. Next steps should help prioritise solutions for overcoming these barriers to present coherent recommendations to government and other planning stakeholders on how to enable information modelling for planning (Figure 37).

The research presented in this project offered themes to focus on for developing solutions, but solutions must be tested and prioritised to ensure that the approach selected will be impactful and value for money. For example, before making large financial investments in hardware for local authorities, one must first understand how much storing BIM files will cost local authorities and what size files they will be storing, as storage may be a hidden cost in implementing information modelling for planning. Furthermore, if data costs are prohibitive, then addressing organisational barriers will be necessary, but not sufficient to enable change. Because all barriers are interrelated, creating a base case to identify what combination of interventions are necessary and sufficient to overcome barriers should be a key output of further research.

Figure 37



Source: own elaboration

A further area of consideration is around the needs of planners, and where software can actually help. Processes of digitalisation are on the one hand driven by the opportunities of technologies and data (e.g. citizens use of google maps, and their capacity to influence traffic flows). On the other hand, processes of digitalisation are demand driven. For the purposes of both static land-use regulation and for strategic planning, there is a need to identify the right processes and software needs, in particular in regard to user-friendliness. There are numerous approaches out, where at times pilot cases, that bring together local authorities need and research may foster the trial-and-error that is needed to identify the best solutions.

One of the next steps for research in this area is to identify the use cases that can deliver the most value to local authorities and the public, where digitalisation can improve outcomes and save money. Additionally, further research must address the kinds of data that a planning information modelling system needs, determine what data is available from local authorities and figure out how to combine necessary data sources to serve strategic planning purposes.

One application that stood out in our case study interviews was the potential to create a digital twin of utility pipes, wires, and other subterranean assets. This example has the potential to enable better maintenance and operations, but it also illustrates potential difficulties of retrofitting the built environment, as creating a subterranean digital twin from scratch may present technical challenges.

In thinking about future applications of information modelling, and the future landscape for digitalisation and planning, it is necessary to consider the implementation of 5G. While most of the interventions we discussed in this report are feasible with current broadband technology, the faster capabilities of 5G may open up a new frontier for real-time information modelling. 5G may also have deeper implications for inequalities across the UK, as its roll-out will not likely be even, though there are some national strategies focused on providing 5G to underserved areas first.

Finally, a major theme that featured in all interviews and our questionnaire was the role that government can play in enabling digitalisation and information modelling for planning. Stakeholders' most frequently expressed wishes for governmental intervention were focused on: support for better cooperation and collaboration horizontally and vertically across organisations; a more easily navigable legislative landscape; user-friendly software; stronger leadership from the government around standards and information modelling uptake, and more funding and investment.

We have argued through this report that information modelling may have value to offer the planning system, and implementing information modelling has the potential to deliver on efficiency and inclusion ambitions expressed by many smart city strategies. Creating an enabling environment for information modelling in planning is no simple feat, as it will involve making changes in complex systems, and committing serious investments of time, focus and capital. However, enabling information modelling would not be the only positive outcome from such an investment: done properly, overcoming the barriers to information modelling will also unlock potential for digitalisation across other areas of the built environment, unlocking value from built environment data for public benefit.

Acknowledgements

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Annexes

Annex I: Table of planning-related documents

Table: Relevant Planning Policy Documents	
Policy document name	**Policy document function**
England's National Planning Policy Framework 2018	Sets out the government's planning policies for England
Cambridge Local Plan (2018)	Serves as the principle planning document for Cambridge
Bristol Local Plan Review **(2018b)**	Reviews of Bristol's planning documents, to help develop updated plans guiding Bristol's develop over the period to 2036.
Scotland's National Planning Framework 3 (2014a)	Provides framework for the spatial development of Scotland as a whole, including 14 national developments identified to deliver the strategy
Scottish Planning Policy (2014b)	Sets out national planning policies that reflect Scottish Ministers' priorities for operation of the planning system and for the development and use of land
Designing Streets: a policy statement for Scotland (2010)	Sets out Scottish Government's policy and technical guidance on street design
Creating Places: a policy statement on architecture and place for Scotland (2013)	Sets out Scottish Government's policy statement on architecture and place
Relevant Scottish planning circulars (various)	Sets out Scottish Government's policy on implementing legislation
Relevant Infrastructure and Energy Planning Policy Documents	
The National Policy Statements (various)	Setting out the government's objectives for the development of nationally significant infrastructure in a particular sector (e.g. energy, transportation, water, waste, etc.) and state,
The Planning Act 2008	Designed to speed up the process for approving new nationally significant infrastructure projects
The Marine and Coastal Access Act 2009	Sets out a strategic marine planning system, mainly applicable to England and Wales, and provides executive devolution to Scottish Ministers of the new marine planning and conservation powers in some regions
The Localism Act 2011	Facilitates the devolution of decision-making powers from central government control to individuals and communities in England
The Growth and Infrastructure Act 2013	Sets out series of reforms intended to reduce red tape that the government considered a hamper to business investment, new infrastructure and job creation
The Infrastructure Act 2015	Makes an independent agency for highways, alters some planning powers and procedures and sets out new provisions governing fracking under people's land

The Housing and Planning Act 2016	Makes widespread changes to housing policy and planning system
Relevant BIM Policy Documents	
ISO 19650 Transition Update (2018)	Offers answers about UK transition to international standards for BIM
Scottish Procurement Policy Note: Implementation of Building Information Modelling within Construction Projects (2017)	Guidance on the implementation of BIM in construction for public projects above £2,000,000 in Scotland
Handbook for the Introduction of Building Information Modelling by the European Public Sector (2017)	Offers central reference point for the introduction of BIM by the European public sector
HM Government's Industrial Strategy for BIM (2012)	Sets out the actions that government and industry shall take to create opportunities for the UK construction sector
Digital Built Britain Level 3 Building Information Modelling - Strategic Plan (2015)	Strategy to achieve Level 3 BIM
Source: own elaboration	

Annex II: List of organisations interviewed

	Case Study	Organisation	Interview Date
1	Misc	Transport for London	Monday, 11 March 2019
2	Misc	Future Cities Catapult	Tuesday, 12 March 2019
3	Scotland	AECOM	Thursday, 14 March 2019
4	Cambridge	Smart Cambridge	Friday, 15 March 2019
5	Cambridge	Greater Cambridge Partnership	Friday, 15 March 2019
6	Cambridge	Greater Cambridge Partnership	Friday, 15 March 2019
7	Misc	L&Q	Tuesday, 19 March 2019
8	Scotland	Highland Council	Tuesday, 19 March 2019
9	Scotland	Highland Council	Tuesday, 19 March 2019
10	Misc	Idox	Thursday, 11 April 2019
11	Bristol	Bristol Is Open	Tuesday, 16 April 2019
12	Bristol	University of Bristol	Wednesday, 17 April 2019
13	Cambridge	Cambridge Ahead	Wednesday, 17 April 2019
14	Misc	We Are Snook	Wednesday, 17 April 2019
15	Bristol	Bristol City Council	Tuesday, 30 April 2019
16	Bristol	Bristol City Council	Wednesday, 1 May 2019
17	Bristol	Bristol City Council	Wednesday, 1 May 2019
18	Bristol	Bristol City Council	Wednesday, 1 May 2019
19	Bristol	Mott MacDonald	Wednesday, 1 May 2019
20	Bristol	Bristol City Council	Wednesday, 1 May 2019
21	Cambridge	Sawston Parish Council	Thursday, 2 May 2019
22	Cambridge	Cambridgeshire County Council	Thursday, 2 May 2019
23	Misc	Solihull Metropolitan Borough Council	Tuesday, 7 May 2019
24	Scotland	Royal Town Planning Institute	Tuesday, 7 May 2019
25	Scotland	Royal Town Planning Institute	Tuesday, 7 May 2019
26	Scotland	HES	Tuesday, 7 May 2019
27	Scotland	Scottish Futures Trust	Wednesday, 8 May 2019
28	Scotland	South Ayrshire Council	Thursday, 9 May 2019
29	Scotland	Scottish Government	Thursday, 9 May 2019
30	Scotland	Scottish Government	Thursday, 9 May 2019
31	Scotland	South Ayrshire Council	Thursday, 9 May 2019
32	Scotland	South Ayrshire Council	Thursday, 9 May 2019
33	Scotland	Scottish Government	Thursday, 9 May 2019
34	Scotland	Scottish Government	Thursday, 9 May 2019
35	Scotland	Highland Council	Friday, 10 May 2019
36	Scotland	Highland Council	Friday, 10 May 2019
37	Scotland	Highland Council	Friday, 10 May 2019
38	Scotland	Highland Council	Friday, 10 May 2019
39	Scotland	Highland Council	Friday, 10 May 2019
40	Cambridge	Combined Authority Vice Chairman/Cambridgeshire County Council	Monday, 13 May 2019
41	Misc	Liverpool City Council	Monday, 13 May 2019
42	Scotland	Loch Lomond & The Trossachs National Park	Tuesday, 14 May 2019
43	Cambridge	Cambridge Shared Planning Service	Wednesday, 15 May 2019
44	Misc	Ministry of Housing, Communities & Local Government	Friday, 17 May 2019
45	Cambridge	North West Cambridge development	Wednesday,29 May 201

Annex III: Table of Codes

Code	Grounded	Code Groups
BIM-related activities/technologies	89	Current activities/technologies
Governance fragmentation	86	Stakeholder/governance
Collaboration/joined-up working	80	Opportunities, needs, system solutions and recommendations
Data sharing	65	Barriers Opportunities, needs, system solutions and recommendations Stakeholder/governance
Technology barriers	58	Barriers
Stakeholder/governance organisational structure	57	Stakeholder/governance
Data needs/opportunities/recs	56	Opportunities, needs, system solutions and recommendations
Current planning tools/tech	54	Current activities/technologies
Stakeholder/governance work practices	52	Stakeholder/governance
Financial barriers	50	Barriers
Governmental needs/opportunities/recs	49	Opportunities, needs, system solutions and recommendations
Use case	48	Current activities/technologies Barriers Opportunities, needs, system solutions and recommendations
Standards needs/opportunities/recs	44	Opportunities, needs, system solutions and recommendations
CIM-related activities/ideas/technologies	44	Current activities/technologies
Financial model	42	Barriers Opportunities, needs, system solutions and recommendations Stakeholder/governance
Reinvigorate strategic planning	39	Opportunities, needs, system solutions and recommendations Stakeholder/governance
City model needs/opportunities/recs	38	Opportunities, needs, system solutions and recommendations
Technology needs/opportunities	32	Opportunities, needs, system solutions and recommendations
Capacity/staffing barriers	31	Barriers
Successful initiatives	31	Current activities/technologies
Organisational/workflow barriers	31	Barriers
Legal barriers	30	Barriers
Skill barriers	29	Barriers
Educational needs/opportunities/recs	29	Opportunities, needs, system solutions and recommendations

Planning system challenges	28	Planning systems
Citizen inclusion initiatives	27	Current activities/technologies
Data storage/servers/file size	27	Barriers
Contextual variations	26	Current activities/technologies
Data ethics issues	25	Barriers
Level of information detail	24	Opportunities, needs, system solutions and recommendations
Features of planning systems	24	Planning systems
Pilot/prototype/trial	23	Current activities/technologies
Procurement	23	Barriers Stakeholder/governance
Need for digitilised/machine readable planning documents	22	Opportunities, needs, system solutions and recommendations
Data quality issues	21	Barriers
Automation needs/opportunities/recs	21	Opportunities, needs, system solutions and recommendations
Citizen inclusion needs/opportunities/recs	21	Opportunities, needs, system solutions and recommendations
Technology partner barriers	20	Barriers
Opportunities in the planning system	20	Planning systems
Organisational change initiatives	20	Current activities/technologies
Organisation cultural mindset barriers	20	Barriers
Digitalisation	20	Current activities/technologies Opportunities, needs, system solutions and recommendations
Lack of standardisation	18	Barriers
Connectivity barriers	17	Barriers
Digital twin	17	Opportunities, needs, system solutions and recommendations
Conflict	16	Barriers
Personnel time needs/opportunities	16	Opportunities, needs, system solutions and recommendations
Leadership needs/opportunities/recs	15	Opportunities, needs, system solutions and recommendations
Scenario building	15	Current activities/technologies Opportunities, needs, system solutions and recommendations
Planning applications	15	Planning systems
Organisational independence/freedom	15	Stakeholder/governance
Local context	15	Planning systems Stakeholder/governance
Maintenance & operations	15	Current activities/technologies
Data security issues	15	Barriers
Scottish Planning Bill	14	Planning systems
Leadership/champions	14	Current activities/technologies

ePlanning	14	Planning systems
PlanTech	13	Current activities/technologies
Educational initiatives	13	Current activities/technologies
Developers	13	Planning systems Barriers Stakeholder/governance
Legal needs/opportunities/recs	12	Opportunities, needs, system solutions and recommendations
Bespoke solutions	12	Barriers
Transportation initiatives	12	Current activities/technologies
Coordination needs/opportunities/recs	12	Opportunities, needs, system solutions and recommendations
Proprietary systems/data	12	Barriers
Technology lock-in	11	Barriers
5G	11	Current activities/technologies
Lack of awareness	11	Barriers
Proactive organisational culture	10	Stakeholder/governance
Financial needs/opportunities/recs	10	Opportunities, needs, system solutions and recommendations
Open source	10	Barriers Opportunities, needs, system solutions and recommendations
Local plan	10	Planning systems
Retrofit	9	Current activities/technologies
Interoperability	9	Barriers Opportunities, needs, system solutions and recommendations
Organisational needs/opportunities/recs	9	Opportunities, needs, system solutions and recommendations
Aging population	8	Barriers
Suggested changes to the planning system	8	Opportunities, needs, system solutions and recommendations
Bottom-up initiatives	8	Opportunities, needs, system solutions and recommendations
Non-interoperability	8	Barriers
Differences in planning systems	6	Planning systems Opportunities, needs, system solutions and recommendations
Smart city	6	Current activities/technologies
Inequality	6	Barriers Opportunities, needs, system solutions and recommendations
Transparency needs/opportunities/recs	6	Opportunities, needs, system solutions and recommendations
Technology uptake	6	Barriers

Technology-driven approach	5	Barriers
Unclear use case	5	Barriers
Connectivity initiatives	5	Current activities/technologies
Resistance/skepticism	5	Barriers
Investments needed	4	Opportunities, needs, system solutions and recommendations
R&D	4	Current activities/technologies
Fluidity in planning needs/opportunities/recs	3	Opportunities, needs, system solutions and recommendations
Path dependency	2	Barriers