Recommendations for a Digital Library for the Construction Sector

Prepared for the Construction Innovation Hub by Mace

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Executive summary

To enable the delivery of better, faster, and greener projects, the *Construction Playbook* recommends using Modern Methods of Construction (MMC), supported by the digital approach defined by the UK BIM Framework. Within the UK BIM Framework, a "library of objects" – part of the project's reference information and shared resources – is suggested. This report seeks to set out in detail the steps required to establish, create, and maintain a Digital Library that supports the framework and unlocks better outcomes.

The concept of the Digital Library is proposed as an approach to creating the frameworks, definitions and eventual creation by clients of an "object-oriented database" of their requirements, specifications, and information suitable for many use cases. These use cases include expressing their needs when appointing (commissioning and procuring) their consultants (RIBA stages 1 to 4); when transmitting their requirements and design as part of contracts to the principal supply chain partners such as main contractors as lead appointed parties who deliver them; and to those parties who maintain them (RIBA stages 5 to 7).

This report outlines five stages required to create a Digital Library and maps the current activities being undertaken by different Government departments against these stages. In addition, the report establishes a framework to manage the Digital Library as a trustworthy source of information, including the requirements to comply with, administrative responsibility, organisational viability, financial sustainability, technological and procedural suitability, system security, and procedural accountability.

The report is intended to help inform Government departments' thinking for a cross-governmental Digital Library to support the strategy set out in the *Construction Playbook*.

Table 1 summarises the main challenges shared by the Government departments and their suppliers during consultation on this topic and how a Digital Library can address them.

Table 1: Main challenges in the construction sector and benefits of using a Digital Library

Current Challenges	How the Digital Library can support
Inefficiency in interpreting client requirements and creating bespoke design solutions for each project	Re-use of standardised and digital requirements across multiple projects – saving time and money
Knowledge transfer across projects	Centralised repository to access needed information across different projects/departments
Specifications open to interpretation	Consistent human- and machine-interpretable specifications
Difficulties for clients in checking compliance between requirements and deliverables across all project stages, generating higher costs, delays, and poor quality	Automatic and semi-automatic compliance checks to save money, time, and improve the quality of projects
Challenging for suppliers to self-check deliverables against requirements before submission	Automatic and semi-automatic compliance self-checks for suppliers before submission to ensure quality
Issues in monitoring performance of assets during the entire lifecycle	Definition of requirements to be monitored during the whole lifecycle

1. Introducing the Digital Library

1.1. Context

Effective information management across the construction sector is impacted by several systemic, economic and organisational influences, as outlined in the *Construction Innovation Hub publication.*

The construction industry network structure is characterised by firms organising around projects, often resulting in fragmentation between stakeholders. One outcome of this is that each project typically develops a bespoke design, meaning Government departments do not realise the value and programme benefits that can be gained by re-using solutions that have already been created and implemented.

As consultants and staff often change between projects, it is also challenging to learn from experience and avoid repeating mistakes. There is no central knowledge base that can be accessed; thus, the process relies mainly on the experience of subject matter experts. Information is often still defined and managed traditionally, for example paper-based or using PDF with very limited harmonisation and standardisation, making it difficult to compare different projects and undertake intelligent procurement across different projects, portfolios, and frameworks (IPA, 2021).

This approach is inefficient in terms of cost and time and compromises the ability to optimise a building's performance. Specifically, requirements are often not harmonised and digitalised as illustrated in the Hub *Government Department Specification Maturity Assessment* report. Therefore, they are open to interpretation, and it is very difficult to measure performance, such as the embodied carbon and operational carbon values, to evaluate the impact of different solutions to make informed decisions.

It is also challenging to verify compliance between requirements and deliverables for quality. As a result, non-compliance is hard to identify early in the process when it is simpler and less costly to correct (e.g. detection of wrong dimension of spaces when the construction is finalised). In addition, the supply chain cannot self-check deliverables against requirements in a (semi-)autonomous way to ensure the quality of the deliverables. Therefore, the checking process is time consuming and repeatable results become overly onerous to deliver.

To address these challenges, a digital approach has been mandated since April 2016 for all centrally funded projects using Building Information Modelling (BIM) (BIM Level 2 requirement based on BS/PAS 1192 series and in 2012 the UK BIM Task Group worked with NBS to launch the National BIM Library). In 2018, with the publication of the international standards on information management using BIM (ISO 19650 series, based on BS/PAS 1192 series), a new Framework called *UK BIM Framework* was established as a reference for implementation of a digital approach for delivery and operation of assets. The UK BIM Framework is included in the *Construction Playbook* as a key element for delivering better, faster and greener.

In 2021, IPA launched the *Transforming Infrastructure Performance: Roadmap to 2030* (TIP2030) with an updated Information Management Mandate based on the UK BIM Framework. The new mandate includes the requirement for departments to have "a digital mechanism for defining its information requirements and then procuring, receiving, assuring, and immutably storing, via a system of record, the information that it procures" (IPA, 2021).

The BS 8541 parts 1-6 provide a range of standards for library objects for architecture, engineering and construction. In addition, BS EN ISO 19650-2 standard, dedicated to the information management process during the delivery phase of assets, defines the need to consider library objects as part of the project's reference information and shared resources. However, details on definition of the library and guidelines on how to establish and manage it are not included in BS EN ISO 19650-2.

This report takes the next step on definitions and guidance on the "library objects", building on the outcomes of the Construction Innovation Hub's '*Defining the Need*' and '*Specification Maturity Assessment*' reports to establish the need and steps required for implementation of a cross-Government departmental "Digital Library". The Digital Library is proposed as an approach to create the frameworks, definitions and eventual creation by clients of "object-oriented databases" of their requirements, specifications, and information to be used to express their needs.

The BS EN ISO 19650-2 is the base for the UK BIM Framework, included in the *Construction Playbook*. For this reason, this report contributes to the implementation of the UK BIM Framework and the principles included in the *Construction Playbook* (Figure [1]).
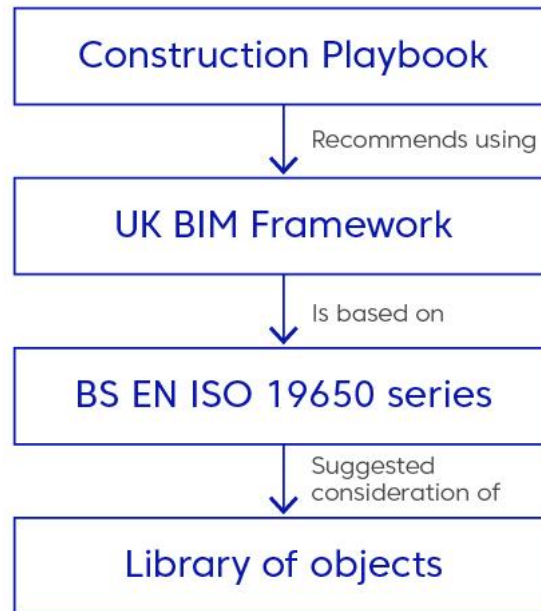
Figure 1 Relation between the Construction Playbook, UK BIM Framework, ISO 19650 series and library objects

This report seeks to:

- Provide the context for a "Digital Library" in the construction sector

- Clearly define the Digital Library in terms of structure and application

- Outline the main functionalities of the Digital Library, with anticipated benefits

- Make recommendations for the process for establishing a Digital Library for UK Government, building on the findings from the Construction Innovation Hub programme to date

- Applying a standard framework for attributes of a Digital Library, outline additional considerations for deployment

1.2. Current Situation

The "*Defining the Need*" report (Hub, 2020) analysed five Departments' requirements and demonstrated the opportunities for standardisation. To overcome the issues described above and be able to drive efficiency and improve value, some departments have created digital libraries that can be used across different projects. Solutions are often documented in PDF or 2D files, requiring consultants to copy them manually before implementation. Other departments decided to make those libraries machine interpretable avoiding re-work.

One example of a Digital Library has been developed by the Ministry of Justice (MoJ), including standard spaces and elements as 3D objects with alphanumeric requirements attached (Figure [2]). Currently, the library is stored in the client's Common Data Environment and shared only with authorised users who have an appointment with the client. The library includes requirements for most common spaces, objects and assemblies included in the department design specifications.
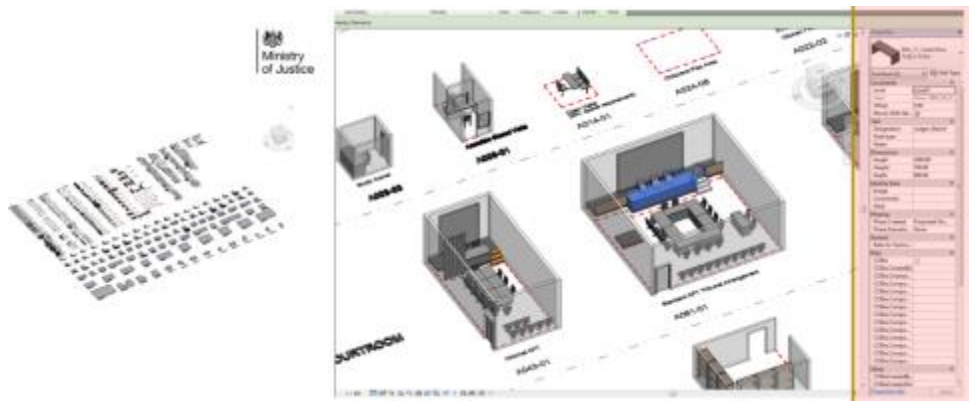

Figure 2 Example of Digital Library developed by MoJ

Other Government departments have started their journey to digitalisation of libraries, but currently there is not a common strategy across Government departments. The *Product Platform Rulebook* defines a 'platform approach' as:

- A set of low variety common assets shared by a set of products. These 'common assets' are typically physical components, but may also include repeated processes, knowledge and relationships. The common assets are replicated multiple times, enabling platform owners to gain competitive advantage by enhancing production or delivery efficiency.

- A complementary set of peripheral components that exhibit high variety. The use of interchangeable peripheral components results in a diversity that creates distinctive offerings to the market.

It is essential to analyse and establish cross-departmental requirements to support an "industrialised" construction industry. This report proposes a definition and management approach for a cross-Departmental Digital Library where each department maintains their own library, while each library is connected and harmonised with the others (Figure [3]). The Digital Library will include core requirements applicable to all Departments Those will be cascaded to department-specific requirements (e.g. for Ministry of Defence, Health, Education, Justice). Additionally, each department will use kits of complementary products for projects including them in the project brief (Figure [3]). This will depend on the delivery models, such integrated or affiliated, where the client is committed to the platform and its complementary products and engages partners who can work with it.
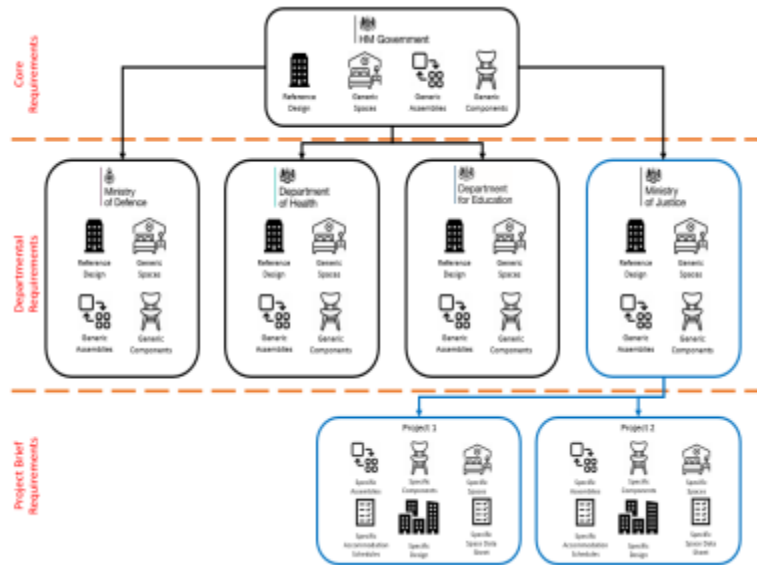
Figure 3 Example of relations between cross-Departmental Digital Library and Department Specific one

1.3. Aim of this report

This report aims to:

a) Provide a definition of a Digital Library;

b) Provide recommendations on the content and extent of a Digital Library;

c) Provide recommendations on the requirements that the Digital Library should comply with; and,

d) Provide recommendations on how to manage a Digital Library.

Note: In this report the use of the verbal form follows the BSI "Rules for the structure and drafting of UK standards": the auxiliary verb "shall" is used to express requirements in a specification, "should" is used to express recommendations, "may" is used to express permission and "can" to express physical possibility. "g" is not used.

2. Definition, content, and extent of the Digital Library

The term "Digital Library" is defined in the standard ISO 5127:*2017 Information and documentation — Foundation and vocabulary* as a;

> "library that provides services associated with digital resources or those aspects of library services that have a large digital component".

At this level the definition is quite generic and not related directly to the construction sector as it relates in general to the scope of ISO/TC 46 responsible for standardisation of practices related to libraries, documentation and information centres, publishing, archives, records management, museum documentation, indexing and abstracting services, and information science. The "Digital Library" is linked to the creation of "digital repositories" where there is already literature covering the constitutional parts. However, the material available on digital repositories/libraries from other domains, such as culture or education, does not consider the peculiarities of the construction sector where Building Information Modelling (BIM) is based on object-based management of information. For this reason, the BS 8541 series of documents provides best practice for the development and application of "library objects" to support BIM-based design, standardisation, specification and construction processes. BS 8541-1 defines the type of (library) object as a;

> "representation of the common features of a product or group, including its classifications and properties".

In the definition it is specified that the type of (library) object can be a template object, generic object or product object. It is independent of any occurrence and has no placement in space.

According to BS 8541-1, a library object should be published in a format that enables the transfer of information, both person-to-person and application-to-application.

According to the Public Procurement Policy from the Crown Commercial Service, Government departments should ensure equal access for all operators to the market in order to maintain open competition. Product-specific objects (e.g. objects that specify a proprietary process, item or product) are not recommended to form part of the scope for a "Digital Library" for Government departments. Product-specific objects are not in the scope of this report, which focuses solely on clients' Digital Libraries.

In addition, the BS 8541 series does not provide any guidance on the management of a library itself as it mainly includes indications for construction drawing practice. It also refers to standards and approaches that have been superseded in the UK (PAS 1192 series).

A "library of objects" can be an essential part of the project's reference information and shared resources as referenced in the BS EN ISO 19650-2 information management process during the delivery phase of assets. This standard is the base for the UK BIM Framework included in the *Construction Playbook* and Information Management Mandate. For this reason, this report contributes to the implementation of the UK BIM Framework and principles included in the *Construction Playbook*. The Digital Library is therefore considered as an access point for suppliers to understand clients' specifications and requirements (i.e. specs are integrated into objects of entities, spaces, elements etc). This report does not cover suppliers' Digital Library content. However, suppliers can create their own digital libraries, but those should be flexible enough to answer clients' needs, providing just the required level of information and no more.

2.1. Content and Extent

Objects can represent different levels of the breakdown structure of an asset: from the entire asset to its overall systems, sub-assemblies, components and the interfaces. For example, a library can contain exemplars of an entire school as well as a ventilation system, a pipe or a valve. However, the objects are product independent as mentioned above. It is important to include different levels of the breakdown structure to support different uses during different phases (see Figure [3]).

The Digital Library can include objects related to:

- entities (e.g. governmental buildings, primary education buildings);

- spaces (e.g. offices, meeting rooms, clean rooms);

- elements (e.g. walls, roofs, air conditioning, lighting); and

- systems (e.g. ventilation systems, refrigerant systems).

The content and extent of the Digital Library will vary depending on department specific needs. For example, the Ministry of Justice might have the need to define performances for specific elements such as cell windows or doors as well as systems e.g. ventilation systems in a secure environment.

Elements and systems are not to be considered product specific as mentioned above, those should be considered generic elements linked to performances included in the specifications.

The classes described above can be linked to classification systems such as Uniclass 2015 to identify components.

2.2. Geometrical and alphanumerical information and need for independent and open standards

The Digital Library can include specifications for geometrical (usually 3-Dimensional – 3D) and alphanumerical (attributes e.g. acoustic rating) information. The standard BS EN 17412-1 on the Level of Information Need should be used to define both aspects. BS EN 17412-1 is included in the UK BIM Framework (see ISO 19650 Guidance Part D).

The definition of geometrical aspects (detail, dimensionality, appearance, location and parametric behaviours) should be provided, taking into account the different purposes that they need to support. The Digital Library does not always include the geometrical representation as this is not always relevant (e.g. performance information).

The alphanumerical information should follow an agreed schema and naming convention. In the UK, the preferred classification system is Uniclass provided by NBS. Uniclass 2015 is also required in the UK national annex to BS EN ISO 19650-2 on information management when using Building Information Modelling (BIM). Uniclass codes should be agreed between the Head of the Digital Library and the Lead of Government Department Digital Library to make sure that specific departmental needs are covered, while at the same time there is a harmonisation across different departments (roles are defined in 5.2).

Additionally, the Construction Innovation Hub and Construction Products Association LEXiCON Project supports the application of the creation and management of product data by standardising the production, use, and management of product data. This will be achieved through the development of a consensus process for the collaborative formation of product data templates.

Note: as Uniclass 2015 is a proprietary system developed by a private company (NBS), its management and development are likely to evolve. Therefore, for a long-term strategy, Government departments should carefully evaluate the risks of creating a Digital Library based on a standard that is subject to market needs. It should be noted that NBS was acquired in November 2020 by the Swedish company (Byggfakta). There may therefore be a strategic requirement for a national classification system defined and managed by the UK Government and aligned with international standards such as ISO 12006-2:2020 Building construction - Organization of information about construction works - Part 2: Framework for classification. However, in the interim period, it is advised to use Uniclass 2015 as it can be mapped later to a different system.

3. Main functionalities

3.1. Flexibility to provide the right information at the right time

The objective of the Digital Library is to support a variety of purposes, functions and activities (e.g. production, energy calculations). In the context of a cross-departmental Digital Library for UK Government, those purposes should be first agreed at cross-departmental level, and then used and further specified at department and project level.

The information content of the Digital Library should be set up in a manner that enables information to be filtered and provided to the individuals/organisations who need them (for example at department, programme or project level). It is therefore important to provide only the information that is needed and avoid the distribution of too much information. The objects in the library will be descriptive in nature and the consultants provide a prescriptive object once they have procured a particular system or product.

The Digital Library can be used independently from configurator tools, however when connected, advanced outcomes can be achieved.

Thus, the Digital Library can be linked to a configurator framework to (Figure [4]):

•   inform design (input)

•   collect standardised outputs

The Digital Library can be considered as input for a configurator to provide information to be used as a starting point (e.g. standard spaces to be used to configure an elementary school). In addition, the output of a configurator (the elementary school) can be used as an updated source for the digital library and a starting point for further projects. In this case, we can consider the Digital Library as part of both the input and output of a configurator.
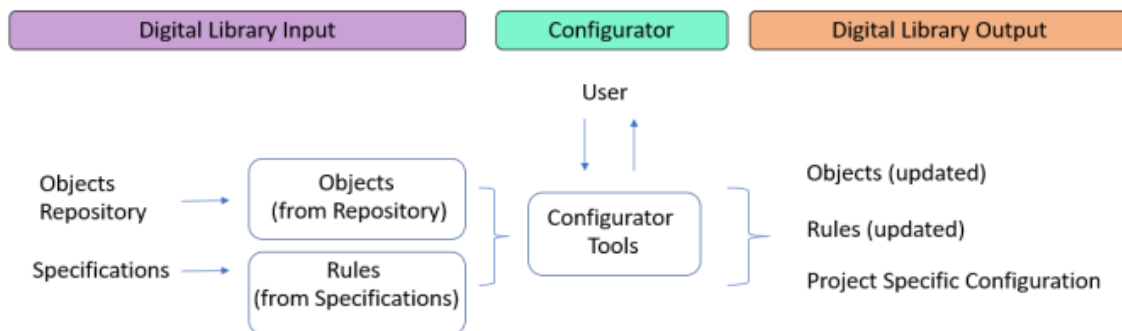

Figure 4 Link between the Digital Library and the Configurator Framework

A Digital Library with a clear and consistent structure and information which is classified accordantly should allow any user to effectively filter information.

For example, during space planning, it should be possible to filter the requirements related to this aspect and transfer to designers so they can focus just on the relevant information (e.g. type and dimension of spaces and their relations).

3.1.1. Openness and interoperability

To ensure open competition, the Digital Library should be set using open standards that should not favour specific software vendors. Interoperability among different applications should be assured without data loss. APIs can be established to connect the Digital Library to different applications as "built-in".

4. Steps to create a Digital Library

An effective Digital Library differs from a traditional library as it requires information to be digital and structured to be machine interpretable. To establish an effective Digital Library, the recommended stages for information readiness are to collect, validate, harmonise, and then structure, so that the information can be digitalised (Figure [5]). Below, we set out the recommended activities within this framework, with anticipated benefits.

The main steps to create a Digital Library are presented in Figure 5. The steps are intended to be applied in an incremental way, supporting a scalable approach, in which an organisation can see value from the ongoing process while investing in its further implementation. For example, it is possible to start the process for certain typologies, then certain estates, then across estates.

Figure 5 Steps to create a Digital Library

4.1. Collect

Gathering different needs

In this phase, requirements from different Government departments are collected to form the basis of the content of the library. Requirements are expected to come from different sources including standards (such as BS EN ISO 19650-2), regulations (such as Building Regulations), specifications (such as DfE output specification), and recommendations (e.g. Design Guidance). Requirements can be collected manually by experts or automatically using text recognition technologies. However, the latter is not well established and often requirements are written in a way that is open to interpretation, requiring input from experts. Sensitive information should be stored in a secure environment and accessed by authorised users only (e.g. following BS EN ISO 19650-5).

Impact: the data collected from five Government departments in 2020 created a foundation to start the process of standardisation and digitalisation of requirements across Government. Without data collection, it is not possible to start the process; it is therefore an essential early step.

4.2. Validate

Select the right needs

In this phase, data collected should be checked by the relevant experts (they can be both internal and/or external to the client organisation) to ensure the dataset is complete and correct. Where there are different opinions on the same requirement, consensus should be agreed.

This phase is fundamental to ensure information of a sufficient quality and maturity is held within the library. The validation process is by nature iterative, and more data might be collected if the initial validation process provides a negative result due to missing or wrong collected information (Figure [5]). At the time of writing, the validation process is mainly manual due to a lack of suitable technology to interpret and validate information automatically.

Impact: the information in the library is accurate thanks to the validation performed by experts where any gaps or errors are identified and solved. Without data validation, use of the library might result in future errors, increasing risk, cost and time of delivery.

4.3. Harmonise

Comparing requirements, finding commonalities and standardising

In this phase, different Government requirements are identified and compared based on different categories identified in the "*Defining the Need*" report (Hub, 2020). As an outcome of the comparison, it is possible to identify differences in specifications where commonality may be anticipated (i.e. office performance specifications) and trying to standardise or rationalise where possible. For example, different requirements for meeting rooms across Government departments are compared and a common requirement agreed (e.g. dimension of the room). If the data is not collected correctly or is open to interpretation, it may be necessary to start the process and validate the information again as an iterative process (Figure [5]).

It is important to stress that harmonisation does not mean over-simplification or making concessions on performance requirements. It implies the removal of unnecessary complexity, and the explicit management of complexity vs perceived value. The manufacturing sector has used both pure complexity reduction and Quality Function Deployment (QFD) as a strategy for many years. In fact, manufacturing complexity reduction has become a crucial performance indicator for a supply chain, and reduction of manufacturing complexity helps drive the improvements required to achieve upper quartile performing operations. Using QFD as a methodology, complexity reduction is balanced against value perceived by the customers, ensuring that over-simplification is not the outcome (more information on QFD can be found in the "*Defining the Need*" report (Hub, 2020)).

Impact: this step is essential to promote a platform approach where both information and physical products are standardised where feasible across different Government departments to support the industrialisation of the construction sector.

4.4. Structure

Define a common data structure

In this phase, an agreed data schema is established. The data schema should be expressed in a way that is verifiable and compatible with existing systems and classifications to allow machine-interpretability. In addition, the data schema should be extensible to allow a gradual extension of information where needed. Protocols and processes for extending the data schema should be in place to prevent corruption and data loss. If the information cannot be translated in a data schema, there might be the need to go back to the previous step and harmonise data in a different way, generating an iterative process (Figure [5]).

Impact: the definition of a data schema is an essential step in creating a database. Without translating the information into a data schema, it is not possible to ensure interoperability and data flow among applications, that is one of the key requirements of Government departments.

4.5. Digitalise

Transfer requirements in a database

In this phase, requirements are transferred into a database. The database can be made up of different sources stored in the departments' servers. However, those sources should be connected, and the content should be coherent.

The content of the database should include a machine-interpretable specification, with instances represented in parametric 3D where needed.

When the Digital Library is finalised, it can start to be used in projects and related appointments. The library should be included as part of the project brief and can be used during invitation to tender for bidders to better understand the

requirements and make more reliable offers. It can also be used after the appointment award to create or develop the design. If users detect missing requirements, new information should be collected starting a new cycle (Figure [5]). The client will use the Digital Library to communicate their needs to the supply chain. For example, they will have a repository for different building typologies (i.e. tribunal, primary school) to inform the supply chain on the performance requirements of components. The designer will then use the library as a reference to develop their proposal (e.g. responding by further developing existing objects or by replacing them).

Impact: this last step allows for more efficient management of information: information can be queried, filtered and shared with the interested parties to support a faster and better delivery of projects. In addition, sustainability aspects can be monitored and different requirements within the Digital Library can be compared more effectively to measure embodied and operational carbon of assets.

4.6. Application

Before starting the creation of a cross-departmental Digital Library, each department should complete the Collect and Validate steps. In this way, requirements for each department are collected and controlled by specialists. At that stage, it is then possible to harmonise cross-government requirements. Once the harmonisation is completed, it is possible to structure the requirements and digitalise them so that they can support the day-to-day activities of each department (see Figure [6]).
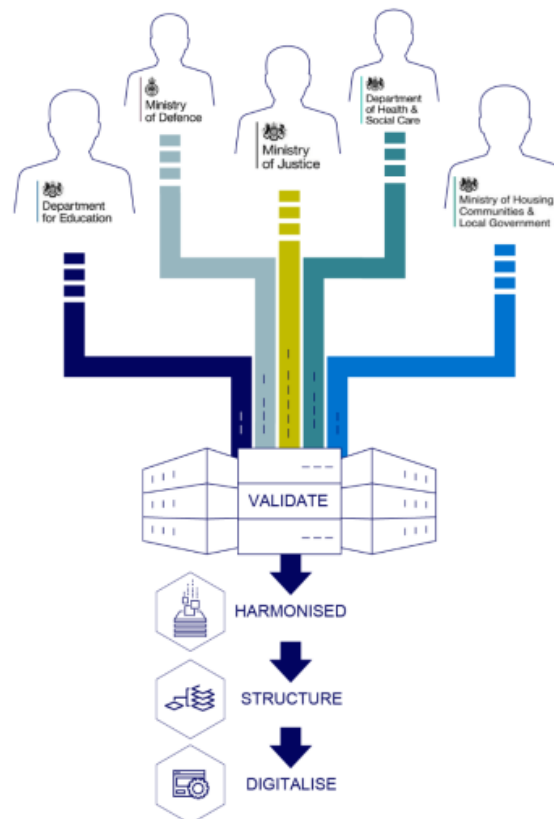

Figure 6 Harmonising, Structuring and Digitalising processes for the Digital Library

5. Attributes of a Trusted Digital Library

The Digital Library should be a trustworthy source of information with relevant and up-to-date content.

To achieve that, a framework should be established. Other industries have been dealing with the creation of digital libraries, most notably of books and multimedia resources. However, there is no guidance on how to manage a library for the construction sector. To expand our understanding of how the sector may implement a Digital Library, a valid report "*Attributes of a Trusted Digital Repository: Meeting the Needs of Research Resources,*" published by the Research Libraries Group and OCLC in 2002, has been used as a reference to develop an outline set of requirements for a cross-departmental government library.

The recommendations are intended as a guide.

The framework includes the following areas, which we apply to the construction sector:

- Requirements to comply with

- Administrative responsibility

- Organisational viability

- Financial sustainability

- Technological and procedural suitability

- System security

- Procedural accountability

5.1. Requirements to comply with

The information in the Digital Library to be captured should be in compliance with:

- Building Regulations;

- Client requirements (Information Requirements); and,

- Any other additional standard to be confirmed by Government departments.

5.1.1. Building Regulations

The content of the Digital Library should comply with Building Regulations at national level. In that way the Digital Library will allow for more effective cascading of changing to the Building Regulations. It might be the case that additional requirements might be added to fulfil other requirements outside the UK if the library should be used overseas (e.g. for military projects in other countries).

The Digital Compliance Network (D-COM) is working on the digitisation of requirements, regulations and compliance checking processes in the built environment.

5.1.2. Appointing Party Requirements

Each Government department has specific requirements that should be as per the TIP IMM identified in the information requirements described in the BS EN ISO 19650 series:

- Organisational Information Requirements;

- Asset Information Requirements;

- Project Information Requirements;

- Exchange Information Requirements; and,

- Security Information Requirements.

The harmonisation should be incremental so that each department can invest appropriate resources and test applicability of solutions. During the harmonise phase, requirements should be taken into account to find similarities and, at the same time, recognise differences for each Government department (e.g. security requirements for the Ministry of Defence). The common minimum requirements should be defined with just a few exceptions in case of specific purposes (e.g. security needs) that might require higher needs.

5.1.3. Machine interpretable requirements to inform the Digital Library

Client requirements and Building Regulations should be set in a machine interpretable way to inform the Digital Library. In this way, it would be possible to autonomously (or semi autonomously) check the compliance between the Digital Library and the requirements included in the Building Regulations and client requirements.

This topic has been led by the Digital Compliance (D-COM) where they look at digital compliance of Regulations, Requirements, Standards and Guidance.

5.2. Administrative Responsibility

Administrative responsibility extends to meeting appropriate standards for backup and recovery procedures, as well as security systems. Those responsibilities should be clearly assigned to the roles presented below in Table 3. The trusted repository will meet or exceed community standards for performance and will collect and share data measurements routinely with users.

It will involve external community experts in validating and/or certifying its processes and procedures on a regular schedule. Written agreements with users will address all appropriate aspects of acquisition, maintenance, access, and withdrawal. Further, ongoing risk management and contingency planning will play a routine part of the organisation's annual strategic planning activities. A reliable repository will commit itself to transparency and accountability in all its actions.

A group of cross-departmental experts should be nominated to keep the library updated once established. A clear ownership with well-defined roles and responsibilities should be established and updated based on the demand of requests and at least annually. Minimum roles should include the Head of the Digital Library, Lead of Government Department Digital Library and Librarian. The Head of the Digital Library and the Lead of Government Department Digital Library are part-time activities, and these people attend a steering group. On the other side, the librarian is a full-time position in a management role. A team of librarians can be established to collect feedback from each Department and update the content. Table 3 presents the responsibilities associated with each role.

Table 3: Roles and Responsibilities associated to the Digital Library

Role	Responsibilities
Head of the Digital Library	This person is responsible for the maintenance of the Digital Library ensuring that it is up to date and usable by all parties. This person is also responsible for financial sustainability (as set out in 5.4).
Lead of Government Department Digital Library	This person represents a specific Government department and is responsible for informing the Head of the Digital Library if updates to the Digital Library are needed and to check the work developed by the Librarian(s). This person is usually part of the Technical Standards team of the Government department represented.
Librarian	This person is responsible for updating the Digital Library based on the feedback provided by the different Leads of Government Department Digital Library.
Practitioners	Users of the library are responsible to provide feedback to the Government Departments on the effectiveness of the Digital Library.

5.3. Organisational Viability

Inter-department collaboration should be established to ensure that each Government department can demonstrate their viability in managing a Digital Library. Each Government department's business strategy should reflect the commitment to the long-term retention, management of, and access to the Digital Library. Staffing levels and areas of expertise will be appropriate to the work undertaken (see previous section); further, staff training and professional development opportunities, including conference attendance and participation, will be given priority to ensure the currency of staff skill sets. The Government departments should continually review their policies and procedures to ensure that appropriate growth can occur, and that new processes and procedures are tested for scalability. At the same time, they should be able to retire, stop or change direction in case of detected issues.

5.4. Financial Sustainability

An investment in the creation and management of the library is required.

A trusted Digital Library will adhere to all good business practices and should have a robust auditable business plan in place. Normal business and financial fitness should be reviewed at least annually to ensure the long-term sustainability of the enterprise as new processes and technologies may arise to improve the useability of the Digital Library. Standard accounting procedures should be used. Both short- and long-term financial planning cycles should be in evidence, demonstrating an ongoing commitment to seeking a balance of risk, benefit, investment, and expenditure. Operating budgets and reserves should be adequate. Development opportunities for new sources of revenue should be explored routinely. All appropriate fiscal practices and conduct should be in place to ensure the sustainability of the Digital Library including the cost of hosting it in an agreed and secure environment (that can be made up also of separated databases interconnected as discussed above).

5.5. Technological and Procedural Suitability

Government will need to ensure that it has in place all appropriate hardware and software to undertake the forms of acquisition, storage, and access. The Digital Library should have policies and plans for replacing technology as needed, including cycles of replacement and funding to achieve them (see Financial Sustainability section). The Digital Library should comply with all relevant standards and best practices included in this report, ensuring that staff have adequate expertise to understand and implement them. It is advised also to undertake regular audits on the system components and performance. This should be done by each Lead of Government Department Digital Library.

5.6. System Security

The Digital Library should be created to assure the security of information included according to ISO/IEC 27001 and 19650-5:2020 principles. Policies and practices should meet Government department requirements, particularly those pertaining to sensitivity, copying processes, required redundancy of data, authentication systems, firewalls, and backup systems. The repository should have written policies and plans for disaster preparedness, response, and recovery, and staff should be trained appropriately. Special attention should be given to processes that address data integrity to avoid loss of data, detect changes in data, and restore lost or corrupted data. Any detected changes (including loss or corruption and restoration) should be documented, and the Head of the Digital Library should be notified both of the changes and any actions taken.

The Digital Library should be hosted in the Government Common Data Environment (CDE) (see Figure [7]). The CDE is not just one tool, but it is an ecosystem of applications, thus the Digital Library can be stored in different databases that, however, are interconnected to ensure coherency of information. It should only be accessible by users with authorisation, including external users (future suppliers). Authorisation is managed in the CDE where people with identified roles have different accessibility rights. The information manager, together with a security expert, should set up the CDE to allow the management of authorisation processes.
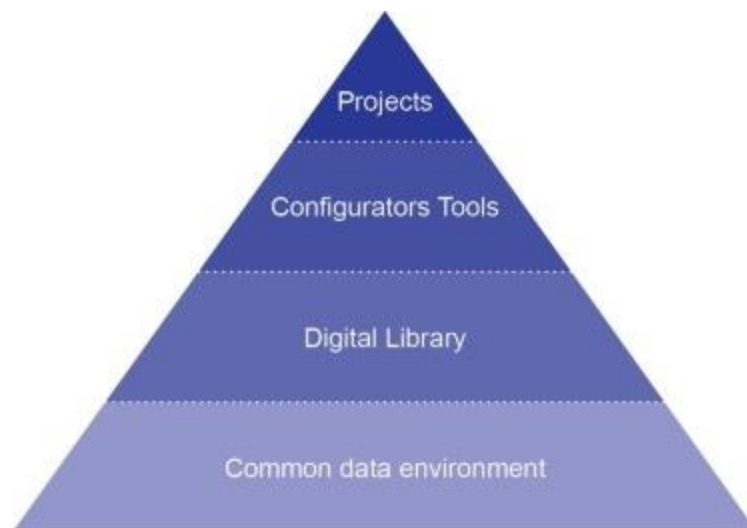
Figure 7 Relationship between CDE, Digital Library, Configurator Tools and Projects

The Digital Library within the CDE solution should:

- be secure;

- be easily accessible to all parties;

- allow automatic compliance checks; and,

- allow reports of compliance checks.

Reports of the compliance checks should be generated automatically within the CDE solution to inform Government departments of any possible issues.

5.7. Procedural Accountability

A trusted Digital Library is responsible for a range of interrelated tasks and functions as described in this report; it should therefore be accountable for all relevant policies and procedures. The practices should be documented and made available on request.

Monitoring mechanisms that measure and ensure the continued operation of all systems and procedures should be in place. Preservation strategies undertaken (e.g., migration, emulation) should be recorded and justified.

Feedback mechanisms should be in place to support the resolution of problems and to negotiate the evolving requirements between the Digital Library, any third-party service providers, and the users.

Therefore, the Digital Library should be updated considering lessons learnt during its application in projects and programmes. For this reason, there should be a reporting mechanism to collect comment from users, as well as processes to automatically verify how the library is used (how many components are used, how many have been modified etc.). The feedback can deal with the content of the Digital Library that informs the configurator (Input) or/and the content of the Digital Library produced by the configurator (Output) (Figure [8]). In the latter case, the feedback will be sent to the configurator to review the rules that establish the configuration. In this way, a lean process based on principles of continuous improvement is established.
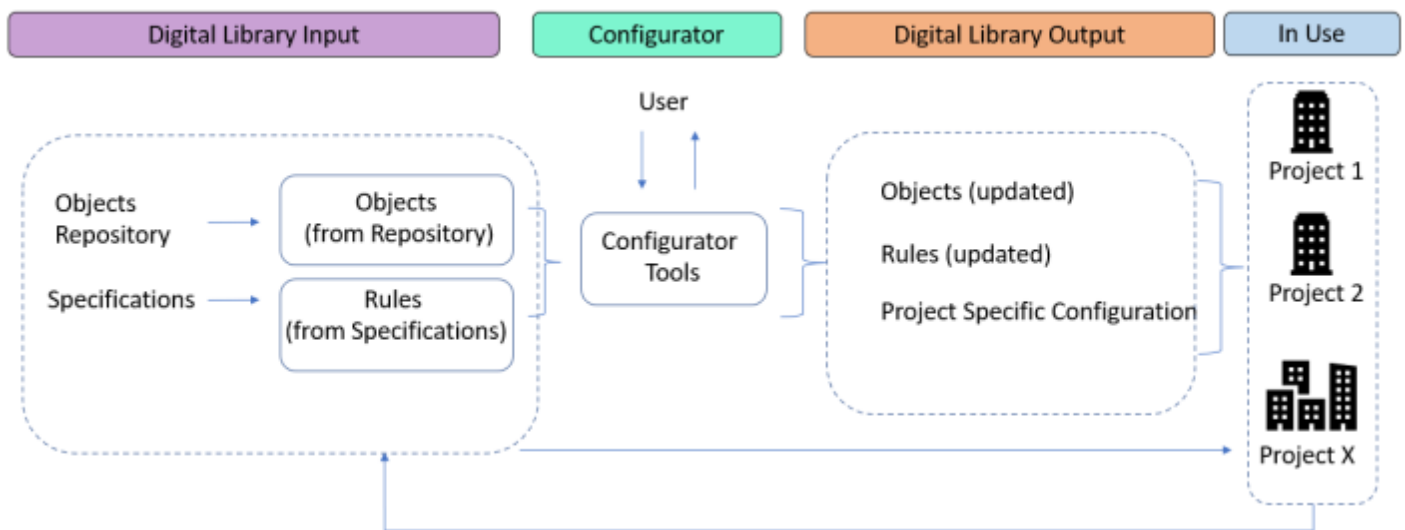

Figure 8 Continuous improvement loop of the Digital Library

6. Current Government departments' activities

It is essential that the steps are undertaken sequentially to avoid waste of resources. The effort required to harmonise and structure the information is significantly higher than the digitalisation for the Digital Library, which can be relatively straightforward if the previous two steps are successfully undertaken. An agile and iterative process should be established and facilitated by collecting feedback and incorporating changes as soon as possible.

For example:

- The Estates Strategy Group has been the first to implement a Digital Library for hospitals called "BIM Health Design Hub" in collaboration with manufacturers. This initiative is managed by a private company (https://bimhealth.co.uk/).

- In 2016, MoJ was a pioneer in collecting requirements from their design specifications and digitalising them in a Digital Library. The structure was defined by using Industry Foundation Classes (IFC) together with the adoption of Uniclass 2015 codes and definition of an agreed naming convention. In 2021 MoJ started the revision of part of their requirements that will inform the update of the Digital Library.

- In 2019, DIO reviewed their building requirements for different typologies and harmonised, structured, and digital exemplar designs were developed. The project was awarded best BIM & Digital Initiative of the Year 2019. Even if the Digital Library were not the main scope of the service, it can be extracted from the exemplar designs produced.

- NHS England and NHS Improvement as part of ProCure22 (P22), a Construction Procurement Framework, established a library of repeatable rooms (https://procure22.nhs.uk/repeatable_rooms_app/03_Consult.html).

- In 2020 the Department for Education started to structure and harmonise their Output Specifications using Uniclass 2015. At the time of writing of this report, DFE is evaluating the digitalisation of their Output Specifications.

Before starting the creation of a cross-departmental Digital Library, each department should complete the Collect and Validate steps. In this way, requirements for each department are collected and controlled by specialists. At that stage, it is then possible to harmonise cross-government requirements. Once the harmonisation is completed, it is possible to structure the requirements and digitalise them so that they can support the day-to-day activities of each department.

7. Conclusions

This report explains the purpose and functionality of a Digital Library for the construction sector, setting out the case for establishing one in practice across Government departments.

Despite identified isolated initiatives of some Government departments to date, currently there is not a cross-Government library that can support MMC, a platform approach or the principles of the *Construction Playbook*.

A Digital Library can help in having repeatable standardised solutions that can save time and money. A centralised repository to access needed information across different departments, consistent human and machine-interpretable specifications, autonomous and semi-autonomous compliance checks will save money and time and improve quality of outcomes. The Digital Library can also allow autonomous and semi-autonomous compliance self-checks for suppliers before submission to ensure quality of deliverables, and it can also help to define requirements to be monitored during the entire lifecycle.

The library should include objects and their geometrical and alphanumerical information at different levels of the breakdown structure of an asset. Naming convention and classification should be used, and open standards should be adopted to ensure open competition in the market.

The main steps to create a Digital Library include collection of requirements, validation, harmonisation, structuring and digitalisation. They are consequential steps, but iterative loops can be created to improve the quality of the content and ensure all requirements are captured.

For maximum effectiveness, the Digital Library should be hosted in a cross-departmental Common Data Environment and linked to a configurator framework as input to inform the configurators as well as to collect outputs. In addition, when the Digital Library is used in projects, a continuous feedback loop should be established to improve both the Digital Library that informs the configurators and the rules of the configurator framework itself to improve the Digital Library output.

Finally, the Digital Library should follow a framework that includes requirements to comply with, administrative responsibility, organisational viability, financial sustainability, technological and procedural suitability, system security and procedural accountability.

7.1. Next Steps

The creation of a Digital Library should follow the steps clearly set out in Section 4. Individual departments have recognised their value and are making progress to procure and populate their own solutions. As recommended by the *Construction Playbook* and the Hub's Platform Programme, investment and effort into developing a cross-governmental Digital Library present opportunities for greater efficiency, productivity and innovation.

The framework proposed by this report has clear actions for each department at the Collect and Validate stages, followed by steps towards a cross-governmental Digital Library which can be coordinated on an ongoing basis by the central Government department or by other impartial initiatives.

8. References

Mace (2022) *Government Department Specification Maturity Assessment.*

Construction Innovation Hub (2020) *Defining the Need.*

Construction Innovation Hub (2020) *Driving transformation, delivering value.*

HM Government (2020) *Construction Playbook.*

IPA (2021) *Transforming Infrastructure Performance: Roadmap to 2030.*

Research Libraries Group and OCLC (2002), *Attributes of a Trusted Digital Repository: Meeting the Needs of Research Resources.*

ISO 19650-1:2018

ISO 19650-2:2018

ISO 19650-3

ISO 19650-5

BS EN 17412-1: 2020 Level of Information Need. Concepts and Principles

ISO 5127:2017 Information and documentation — Foundation and vocabulary

BS 8541-1

ISO/IEC 27001, Information technology — Security techniques — Information security management

systems — Requirements

Key project contacts

Prepare for:	Construction Innovation Hub
Principal Contact	Name: Dr. Marzia Bolpagni E-mail: marzia.bolpagni@macegroup.com
Construction Innovation Hub Contact	Name: Jonny Reid E-mail: jonathan.reid@the-mtc.org
Contributors	Buro Happold BSI CDBB Construction Innovation Hub Grimshaw Mace Manufacturing Technology Centre (MTC) Mott MacDonald UK BIM Alliance

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