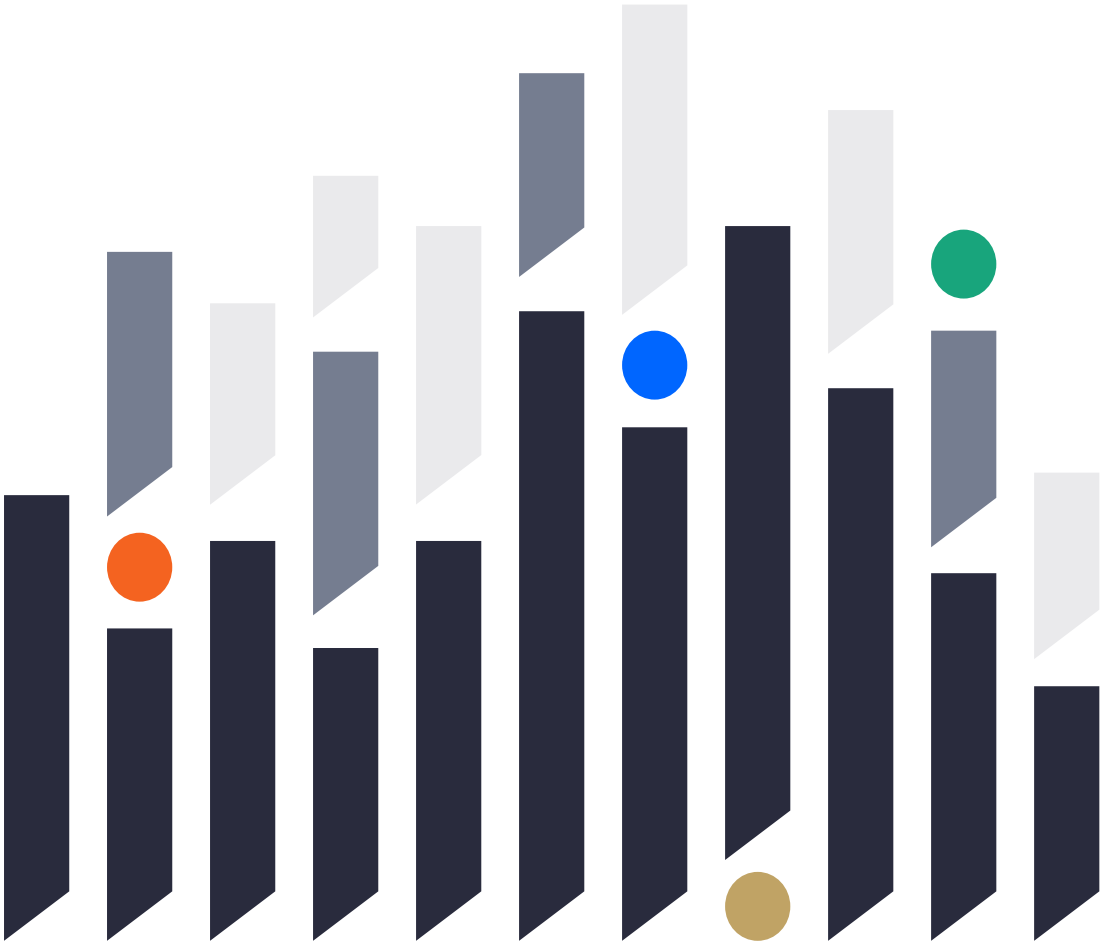
CDBB L2C PROGRAMME

Standards landscape and information management systems



urban innovation labs

WP0: Executive Summary

© urban innovation labs

Introduction

The purpose of the Level 2 convergence programme is to establish the relationship between the citizens and users of assets with the assets planned, designed, built, maintained and operated. This would allow the leveraging of socioeconomic outcomes with the assets constructed. The purpose of this workstream is to test whether the existing suite of de jure or de facto standards enable the establishment of the whole asset lifecycle end-to-end relationship and if not, identify areas needing further work to be undertaken and challenges in doing so.

This workstream for the Centre for Digital Build Britain is scoped to:

- Understand how standards can be developed and achieve maximum adoption in emerging markets and subject areas.
- Describe the standards landscape within the scope of CDBB.
- Develop meta-standard mapping for BS 1192: 5, PAS185, ISO55000 and ISO55002.
- Extend the standards landscape to develop information pathways throughout a service line and asset lifecycle within three high value sectors.
- Produce an objective assessment of the existing BIM data structures of IFC and COBie, and their ability to provide the functionality as identified by an expert panel representing market requirement.
- Suggest recommendations to all bodies concerned with producing standards, specification, or guidance, whether de jure or de facto, about how the existing and new standards within the scope of CDBB could be developed.
- Design an experiment to test the whether the data identified as part of the information pathways can be integrated using the techniques currently available.

© urban innovation labs

Main findings and observations

The main observations and findings have been:

- The breadth of the mission of CDBB will touch a large number of existing communities who will need to be integrated into the future landscape if adoption and impact is to be assured. For example, even with careful scoping of the searches there are over 11,000 de jure standards that are in scope, and an anticipated similar number of de facto standards within sectoral groups. To illustrate the complexity, the diagram in Figure 1 shows the relationship between a sub-set of 11,000 of the de jure standards within scope of CDBB. The orange hot spot is in fact a black hole where orphan standards are concentrated. The rest of the diagram shows the linkages across the standards.

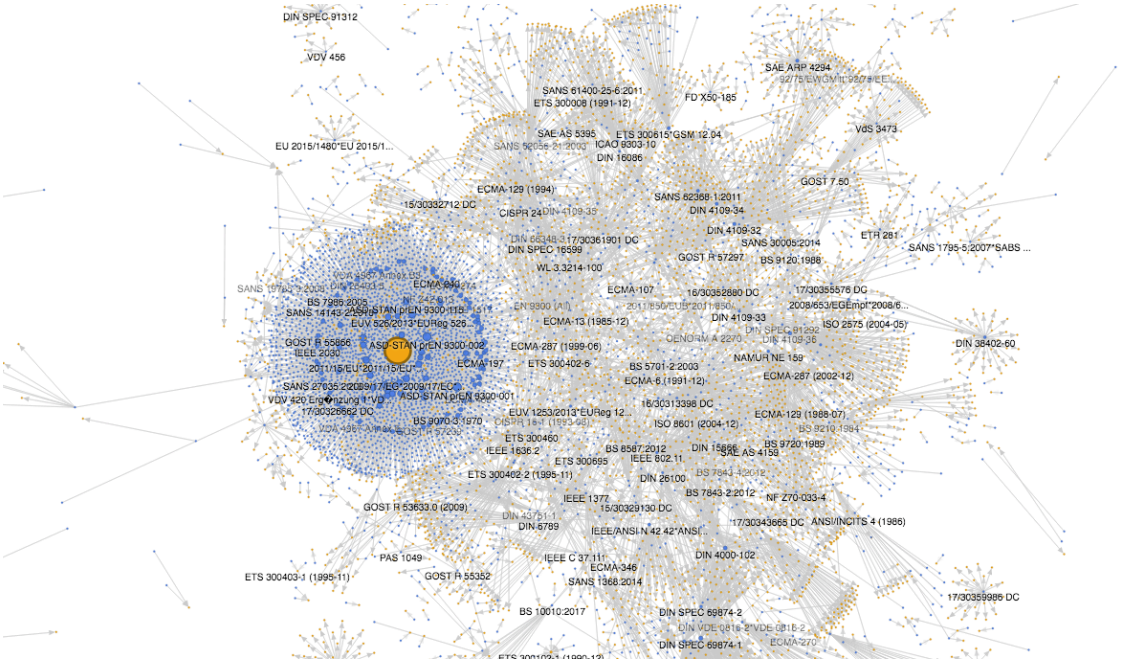


Figure 1 - Relationship diagram of sub-set of de jure standards within the scope of CDBB

- The term standard is misunderstood and often misused. There are national de jure standards designed to coalesce experience and codify, and publicly available specifications to test the market with a defined way of doing things. Then there are numerous de facto standards, guidelines and codes of practice that exist at a national level, within sectors and for specific organisations. They all serve a purpose and the most appropriate method for achieving the desired outcome needs to be selected.
- The ISO9001, ISO41000, ISO51001, ISO13972 and PAS181 quality management processes for the different sectors provide an excellent framework for the definition of a management system of which the ability of the enterprise is to be described, but there are not any standards identified that explain how that ability should be described.
- The greatest lifecycle potential for CDBB is the service provision and the associated socioeconomic impact, yet this area is the least served by existing standards.
- The existing de jure and de facto standards almost exclusively describe how things are to be realised and, using the management system standards, a framework in which the activities needed to achieve an outcome can be structured. However, there is a gap in defining how the outcome will be achieved and how to measure the outcome in terms that can be codified.

© urban innovation labs

- Definition of a service outcomes are required in terms that allow different actors within and across the value chains to trade information.
- A proposed definition of service outcomes is proposed, using a model of Capability, Capacity, State and Quality of Service (CCSQoS) to provide the framework where the ability of a service can be described in terms of what is to provide, how much of it available, what has/is/will it do and has it achieved the required performance levels.
- This model of CCSQoS could address the gap between the management system framework standards and the detailed standards at a level that would allow different systems to transact information applicable to achieving the desired outcomes. After this, the existing standard structure or abstracted meta standard framework should be used to provide the underpinning detail.
- Creating a model where a service outcome can be described will create new challenges. Today choices are made and priorities are set by a multitude of individuals at various stages in the process. An integrated model view will require interventions or rules sets for choices and priorities to be established. These may be engineering decisions, but more likely they will become ethical choices that will have implications and needs further investigation.
- The nature of service provision in many cases will involve using personal data and data that has security implications. How these issues are to be addressed will need further investigation.
- The progress made should not be forgotten and continued efforts need to be made to ensure the fundamentals of Level 2 are established, and that demonstrators are used as test cases to push the boundaries and help upskill the exiting market.
- Our expert groups and wider market engagement reiterated the importance of this being a market driven activity focussed on the outcomes, and not a solution driven ICT project.
- Our market sensing suggested a method of abstracting the task of managing complex data away from the user would and focus on the outcome they seek to achieve would accelerate adoption and impact of application.
- There is an existing information infrastructure within all of the sectors and even with all its limitations, it does function. The existing world view and legacy systems will need to be carefully considered as part of any roadmap development.
- If the market is to take an active role, we will need to form communities of experts able to understand the different sectoral value chains and the information needed to exploit these.
- The business case and options for any of the interventions mentioned needs to be established.

Standard development

Standards are codified knowledge. They express the work and experience. They define how technologies, interfaces and products must be made in order to work properly and fit together. Consider connecting a kettle to a power station, you do not need to understand the complexities of energy generation, transmission or distribution, you just need a 3-pin plug and a corresponding socket. Yet even this simple example of standardising the domestic device to grid interface has proliferated to 15 types of plugs and sockets across the World[1].

The importance of standards was established in the first industrial revolution as parts for different machines were needed to interoperate. As we enter the fourth industrial revolution with the mission

[1] https://www.worldstandards.eu/electricity/plugs-and-sockets/

of CDBB in mind, the ability for the different elements of the data that describes natural and built environment to integrate data to drive service and socioeconomic improvement is paramount.

How the definition is described, in a code of practice, guideline, PAS, National or International Standard needs careful consideration to ensure the balance between pace of development and crystallisation of a broad community. This is illustrated with the roadmap in Figure 2. This shows that that early development needs agility with the focus of industry groups to produce guidelines or de facto standards. As the thinking develops, the increased clarity can be captured in a Publicly Available Specification (PAS) to test market adoption before a National or International Standard is established. In areas where the pace of change is rapid, for example, computer science or telecoms, the industry groups generally take the development lead as with the W3C or 3GPP.

It is anticipated that CDBB will have a mixture of all of these types of standards in scope, from very specific technical standards to the definition of service outcomes, with a variety of approaches from rapid iteration to the crystallisation of consensus. This will require establishing legitimacy in the market and the coordination of a diverse and broad series of stakeholders often with differing needs.

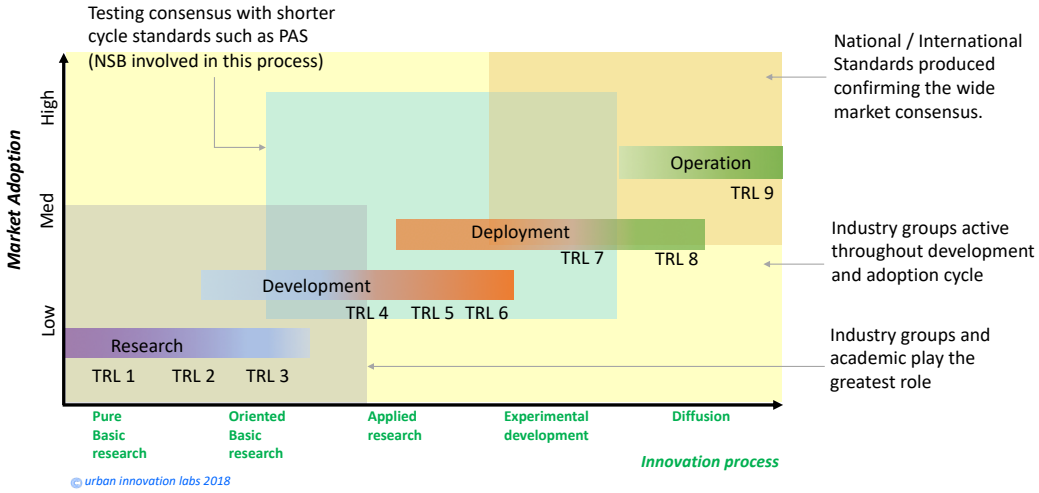


Figure 2 – Standardisation evolution roadmap

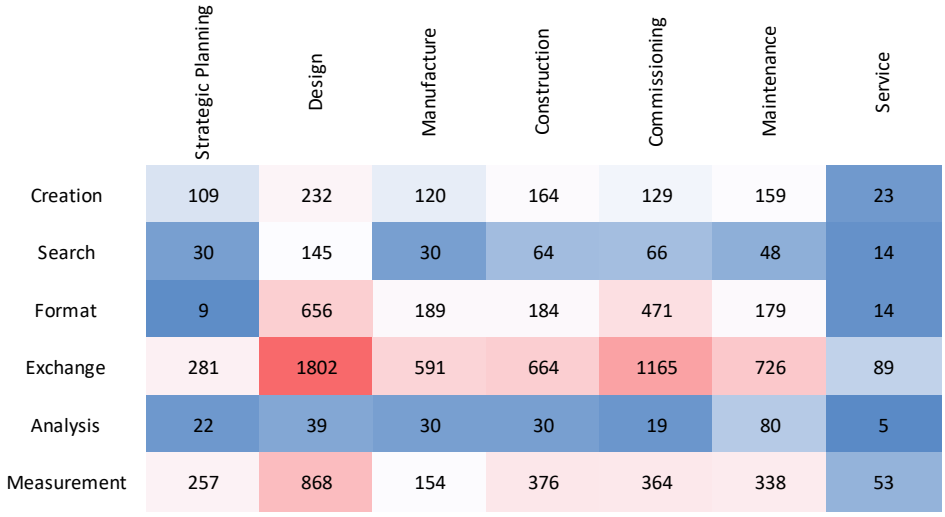
Standards landscape

The large number of standards in scope and the absence of a logical network, as shown by Figure 1, indicates little coordination with numerous groups working in isolation to address specific needs. Reflecting on the number of domestic plugs and sockets, to create single standards within such broad communities within the scope of CDBB will be a challenge and it is suggested a means of managing the inherent complexity will be required.

To obtain further insight into the standards, the conventional approach to standards mapping has been developed by UIL to include a so called broad:deep method. This allows the analysis to be undertaken at a broad sectoral level and then deep dive into specific use cases to see how prevalent the respective standards are. As indicated by Figure 1, the number of standards within scope is vast, therefore the ability to determine applicability will be paramount.

The analysis is based on number of standards deemed to be applicable, not the quality nor the impact the standard has on the market. This approach has been taken as the tools do not yet exist that allow

for these other factors to be considered. The analysis has indicated that the standards landscape within the scope of maximum impact by CDBB, service provision, is the most scarcely described by de jure standards, namely service and strategic planning as shown in Figure 3. However, subsequent analysis has indicated that de facto standards are more prevalent in this stage of the lifecycle. It should also be noted that having more is not necessarily a good thing, especially in the area of exchange where one would expect fewer but more pervasive standards to exist. Whilst having a large number is indicative of a fragmented market.



	Strategic Planning	Design	Manufacture	Construction	Commissioning	Maintenance	Service
Creation	109	232	120	164	129	159	23
Search	30	145	30	64	66	48	14
Format	9	656	189	184	471	179	14
Exchange	281	1802	591	664	1165	726	89
Analysis	22	39	30	30	19	80	5
Measurement	257	868	154	376	364	338	53

Figure 3 – De jure standards in the asset and data lifecycle (red = many, blue = few)

Meta standard

A meta-standard is a standard of standards[2], enabling technical and non-technical standards to be combined in a structured form, by focussing on elements pertaining to the competencies (what the standard seeks to address), capabilities (what is being assessed) and components (the guidance provided in a standard). This enables a broader and deeper perspective of the standards to be achieved, makes working with multiple standards possible and highlights duplication, conflict or gaps that need resolution.

The concept of meta standards was developed to provide a method of taking a perspective across a number of different and often disparate standards to achieve additional feature and functionality impossible with an existing standard set. It has been shown to help with the discoverability of the correct standard by focusing the user's attention to the appropriate area and providing a logical order of often abstract definitions, particularly through a lifecycle.

The process of creating a meta standard is quite time consuming, subjective and reliant on diligent expert knowledge. Development of a tool to assist the process would be of benefit. Furthermore, the standards databases like Perinorm do not record information at a clause level. The BSI online tool is a publishing portal that gives access to flat files but not in a machine readable or searchable form. These are factors that would benefit from addressing, particularly when the overall landscape is so complex.

[2] https://doi.org/10.1016/j.csi.2017.06.002

The meta-standard concept has been successfully proven with further use cases of ISO55001, ISO55002, BS1192:7 and PAS185. These meta-standards can now be used to ensure that actions taken from the perspective of a city leader or service provider will be cognisant of the needs of the asset manager, constructor and planner. Any use of the standards by these actors should be with expert support to ensure correct application and to gather feedback to refine. The meta-standards have also highlighted a series of areas for consideration in future standard updates.

Having established and tested the methodology and reflected on the complexity of the standards landscape, it has highlighted the future benefit for automated conformance checking of products and services against the standards, guidelines and codes of practice in both their individual and meta-standards forms.

Information pathways

Information pathways trace information about the service provision and asset requirements for the purpose of planning, designing, building, maintaining and/or operating the asset to fulfil the outcomes and performance objectives set out in the use case and vice versa. This ensures there is continuity of definition of both the process and data. Without this continuity the it will not be possible to leverage the socioeconomic benefit of an asset. The hypothesis has been successfully tested to show Smart City standards and BIM standards can be linked, aligned and augmented to enable these pathways to be established.

Three use cases were selected: demand side regulation of electricity, integrated traffic management at a network (urban/extra-urban) level, and care of the elderly and the impact of hospital bed blocking.

For each use case, a comprehensive standards assessment was undertaken. In all cases, even after careful key word selection to focus the search, around 2,000 candidate applicable standards were identified. After further detailed analysis, this was reduced to between 5 to 20 that describe information for the service and associated asset lifecycle.

The pathways were established through the abstraction of the service layer and association of the assets required to provide the service throughout the assets lifecycle. The assets can be described using the existing IFC or COBie data structures, and this will allow for easy migration to a future state.

For demand side regulation of electricity, the pathway was established with relative ease as the network is contained with a series of assets that are well defined. When the information required to describe the service was analysed, it was found transmission level information existed and is described by international standards. As you move from transmission to distribution to use, the information is contained within National Grid codes, the Distribution Network Operators or the smart meter data collection service, DCC. At a device level there is no definition for the purpose of demand regulation.

The transport pathway proved to be a challenge to construct at an abstracted level due to the complexity in the network description, the actors and the interaction with other modes. That said, it was constructed, and the information needed for the service identified. This information was described in a range of standards that are focussed on a mixture of device and service.

The healthcare pathway was by far the most challenging as the association of the service and the asset was the most decoupled. A range of well-defined rules governs the healthcare facility, then execution of the service occurs within the confines of the facility with very little interaction with the direct

outcome. The equipment within the facility is more closely coupled as it directly involved the service provision.

One of the key principles of the information pathways was the service providing the socioeconomic benefit could be described in terms of its capability and capacity, informed by its state, and provides a measure of quality of service. This is key, as it allows for a consolidated catalogue of information to be surfaced at a service layer, making it possible for different services to interact with just the key information to describe what it does with much of it available.

None of the use cases had de jure or de facto standards identified that described the capability of the assets associated with the service. Capacity was described, but in engineering terms rather than the amount of a capability available. The state is discoverable from analytics of available information and the quality of service is defined but would benefit from being associated with the capability and capacity.

This approach where the service is abstracted to defining the capability, capacity, state and quality of service and identifying the associated information has been shown to provide a framework in which different standards can be assessed and gaps in functionality defined. It is suggested the approach is tested on further pathways to increase confidence in the approach. Then a guideline produced that can be used in the market to begin the process of advocacy and, if applicable, crystallised in the appropriate form of standard. This is illustrated in Figure 4 and is explained in detail in WP3.

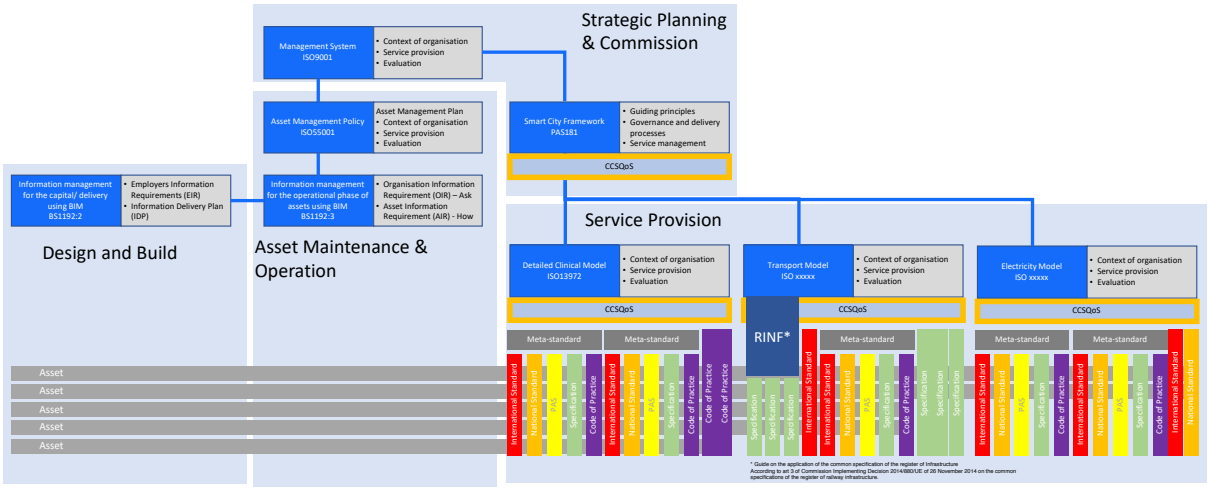


Figure 4 - Overall asset and service outcome lifecycle framework

An experiment has been designed based on the demand side regulation use case. This would test the concept of CCSQoS and associated standards, along with the ability to access and use the information to trace this through the lifecycle. It can also describe if a service is providing what is needed.

Existing data structures

Industry Foundation Classes (IFC) and the Construction, Operation and Building information exchange (COBie) have been shown to admirably achieve the function they are intended for, as described in their respective standards. This has been illustrated in the plethora of projects completed across a range of sectors around the world. It has been shown that many of the issues reported, and the

folklore that develops around this, is caused by a mixture of the following: asking for things that were not contemplated in the data structures, incorrect implementations, or the features being unavailable at this point in time. This has highlighted the need for training and awareness activities to continue, ensuring this basic capability is embedded throughout the supply chain and client base, along with demonstrators that can showcase what is possible to achieve. At the same time, it is important to recognise that if a market need for enhancements to the existing structures are required, these should be considered.

Expert panels were formed around the market demand and solution. The expert panel discussion has highlighted the size of the CDBB mission and ambition for the market, and the impact the necessary changes will have at a human, technical and operational level. There are numerous sectoral legacy systems providing some of the functionality to support the outcomes that CDBB seek to address and these need to be part the landscape. Fundamental challenges around classification exist; for example: what do you call something that exists in a variety of sectors for different purposes and has different requirements? These all need to be resolved, but the message was very clear - focus on the points of interface and not try to re-define what already works.

Recommendations to all bodies concerned with producing standards, specification, guidance,

The original title of this work package was 'Recommendations to National Standards Bodies'. However, through our work it has become apparent that the National Standards Bodies are one of many different groups who are involved in the creation and management of what are generically known as standards. The work in WP1 identified there are number of key stakeholder communities that all fulfil a vital role in the provision of de jure international and national standards, along with de facto guidelines and codes of practice. Therefore, the scope of this work package has been extended to include any organisation that is involved in the development of documents that represent a collective view of informed parties.

The recommendations to all bodies concerned with producing standards, specifications and guidance will not be a list of clause changes for specific standards; a number have been identified in WP2 for the meta standards. This is because there are a number of fundamental aspects for consideration regarding standardisation and the role of CDBB in this process of standardisation.

This work package has identified the main of areas of recommendation as follows:

1. Roadmap for standardisation:
    a. Identify the scope of the mission requiring standardisation, the parties currently involved and the parties that should be involved, and develop a roadmap for the standardisation.
    b. Include the development, consolidation or removal of the existing standards as part of the roadmap for CDBB, to ensure maximum value is extracted.
    c. Establish a roadmap for defining or surfacing existing standards in the service provision stage of the lifecycle.
2. Support adoption:
    a. Establish a capability within CDBB or its community for the detailed understanding of how standardisation can be developed and used to drive market change.

b. Continue to support market adoption of current standards through training and masterclasses.
c. Identify a range of demonstrators to illustrate the capability of what can be done using existing approaches and how it has been achieved, particularly around areas where there is a national imperative. This should be completed at the same time as identifying areas for improvement and trying new approaches or developments in a safe environment.
d. Develop business cases for the benefit of standardisation in service provision.
e. Test the meta standards developed and identify further meta standards to be analysed by market feedback.

3. Develop further:
    a. Further develop the Capability, Capacity, State and Quality of Service definition or for service provision.
    b. Develop a service architectural framework with a focus on public services, from which the standards appropriate for that service can be associated or developed.
    c. Develop a lifecycle and value chain architectural framework with a focus on public services, from which the standards appropriate for that service can be associated or developed.
    d. Develop a method of creating semantic standards that can be linked and searched at clausal level as part of smart standards.
    e. Develop methods and demonstrate viability for compliance checking of standards, guidance, codes of practice and regulation.
    f. Establish a method of including verified de facto standards into the landscape of actionable and smart standards for CDBB.
    g. Understand the ethical issues that will arise when the new business and service model enabled with standardisation.

© urban innovation labs

Concluding remarks

Considerable work has been undertaken by the sector to define and embed Level 2. It is essential this work is not undermined, but acts as a foundation from which further levels of maturity can be established.

The Level 2 convergence standards landscape and information management systems has demonstrated the importance of standardisation to the future of CDBB. However, the vast number of de jure and de facto standards means abstraction and alignment to future levels of maturity will be necessary to make use of what exists and provide a framework in which the existing and future systems can work together. Whether it is feasible to define everything or whether the interfaces between systems at a level of abstraction is an option, needs to be determined.

The approach of defining the outcome of a particular service is essential. The CCSQoS model has been demonstrated as a potential approach that can provide abstraction and framework to the existing world.

Expert groups have shown the existing approaches can be exploited further with training and demonstration. They have also demonstrated that legacy systems need to be considered as part of an overall road map within the change programme, and that the road map needs to be owned by the market and not become led by an ICT solution. There will be an inherent complexity with the data, whether the sector needs to understand this complexity or whether the ICT could abstract this complexity should also be explored.

There are some significant technical challenges associated with creating a standards landscape, data model and a maturity pathway of levels to fulfil the mission of CDBB. The authors believe solutions can be found using approaches available today and those emerging in the short to medium term. However, the ethical questions raised by the analysis will need significantly more consideration as they will directly impact Government policy and any citizen affected system level decisions or codified rule sets.

Recommendations for further work

The individual work packages have identified various recommendations for consideration. This section aims to capture the key aspects collected into two categories: the things we understand and know what to do and the things we do not understand (or understand well enough) and will need research to progress comprehension.

1. Subject area understood, do work:

- Identify scope of the mission requiring standardisation, the parties currently involved and the parties that should be involved, and develop a roadmap for the standardisation.
- Hold training and masterclasses on the use of COBie/IFC with the public and private sector.
- Encourage vendors to provide tools that reduce the need for understanding the details ‘under the bonnet’ but supports the integration of information throughout the asset lifecycle.
- Establish case studies and demonstrators for new and difficult application such as infrastructure, M&E and measurement, and common challenges such as round tripping and data loss.
- To ensure maximum value is extracted, include the development of the existing standards as part of the roadmap for CDBB.

- Establish a roadmap for defining or surfacing existing standards in the service provision stage of the lifecycle.
- Develop tools to construct meta standards.
- Test meta standards.
- Refine information pathways to standard clause, and generate further meta standards.
- Develop methods and demonstrate viability for compliance checking of standards, guidance, codes of practice and regulation.
- Further develop the Capability, Capacity, State and Quality of Service definition for service provision.
- Develop a service architectural framework with a focus on public services, from which the standards appropriate for that service can be associated or developed.
- Develop a lifecycle and value chain architectural framework with a focus on public services, from which the standards appropriate for that service can be associated or developed.
- Develop a method of creating semantic standards that can be linked and searched at clausal level as part of smart standards.
- Refine the standards landscape.
- Create further use cases and develop socioeconomic benefits cases. (Note: there are some areas we know and many we do not.)
- Develop the relationship of data structures with GIS.
- Develop a roadmap for developing communities around challenges and standards to form the basis of industrial groups.
- The current data structures and legacy systems have a future and should continue to be developed as part of the development landscape for the future of CDBB. All of these aspects should be considered as part of an integrated roadmap for the centre.
- Establish a method of including verified de facto standards into the landscape of actionable and smart standards for CDBB.
- Establish a capability within CDBB or its community for the detailed understanding of how standardisation can be developed and used to drive market change.
- Execute the test case defined in WP6.

2. Subject area not understood, needs research:

- The ethics around priority setting and decision making with multiple sub-system operators within (semi-)autonomous systems.
- The measurement of perception and inclusion with closed loop systems.
- Create further use cases and develop socioeconomic benefits cases.
- How will social inclusion be impacted by more information about the social impact of the environment.
- The trade-off between privacy and personal benefit.
- Determination of provenance in highly distributed systems.
- Determination of trust in highly distributed systems.

© urban innovation labs

Acknowledgements

The programme leads, Andy Robinson and Teresa Gonzalez Rico, would like to thank and recognise all those who contributed to this assignment.

Name	Job Title	Organisation
Alford, Karen	FCRM Manager	Environment Agency
Argyropoulos, Dr Miltos	Surgical Resident	NHS
Ball, Kevin	Senior Engineer	Energy Systems Catapult
Bew, Dr Mark	Chair Strategic Advisor Previous chair	PCSG CDBB BIM Task Group
Bossert, Patrick	Associate Partner	EY
Boulton, Dr Charles	Advisor	CDBB University of Cambridge
Brikalis, Dr Ioannis	Academic Advisor	CDBB University of Cambridge
Collins, Carl	Consultant	CIBSE
Cook, Al	Consultant Previous member	CPNI DBB
Cowell, Andrew	Director past-President	Stantec Treatment BIM4Water
Crocker, Rachael	Manager	Mockley Manor Health Care
Davila Delgado, Dr Manuel	Research Fellow	University of the West of England
de Lange, Louisa	Director	LdL
Denton, Ross	Head of Information Management	Crossrail
Eskelinen, Jarmo	CTO Member Vice chair Chair	Future Cities Catapult SmartLondon Board Open and Agile Smart Cities Chair IoT for Smart Cities and Communities Group for EU
Galloway, Doug	Head of Engineering, Power Systems	National Grid
Heaton, James	PhD student BIM Manager	University of Cambridge Costain
Hitchcock, Roz	Solutions Development Manager	BSI
Hutchinson, Nick	Managing Director	GliderBIM
Marsal, Dr Lluïsa	Director	Intelligneter
Millard, Keiran	Standards Consultant	BSI
Nesbitt, Nick	Director Vice-chair	AEC3 buildingSMART International
Nocetti, Colin	Senior Developer,	Business Collaborator, GroupBC
North, Dr. Robin	CEO	Immense Transport Simulations
Palmer, Dan	Head of Smart Cities	BSI
Parkinson, Kieran	Market development manager	BSI
Pearson, Simon	Head of Digital	Energy Systems Catapult
Rawlinson, Simon	Partner Previous Member Previous Member	Arcadis BIM Task Group DBB

© urban innovation labs

Richards, Mervyn	Consultant Author of author of 1192:2 :4 Previous Member	University of Reading BIM Task Group BIM Task Group
Ritchie, Zoey	Senior BIM consultant	PCSG
Rukuts, Steve	Technical Director	Glider BIM
Schooling, Dr Jennifer	Director CISC	University of Cambridge
Schwarzenbach, Julian	Director	DP Advantage
Serrano, David	Manager, Knowledge Centre	BSI
Smith, Paul	Smart Infrastructure Systems Consultant	UIL
Taborda, Sofia	Intelligent mobility and sustainable transport Consultant	UIL

urban innovation labs

Dr. Andrew Robinson
t. +44 7484 214 093
e. arobinson@uil.io

Teresa Gonzalez Rico
t. +44 7487 780 543
e. tgr@uil.io

© urban innovation labs