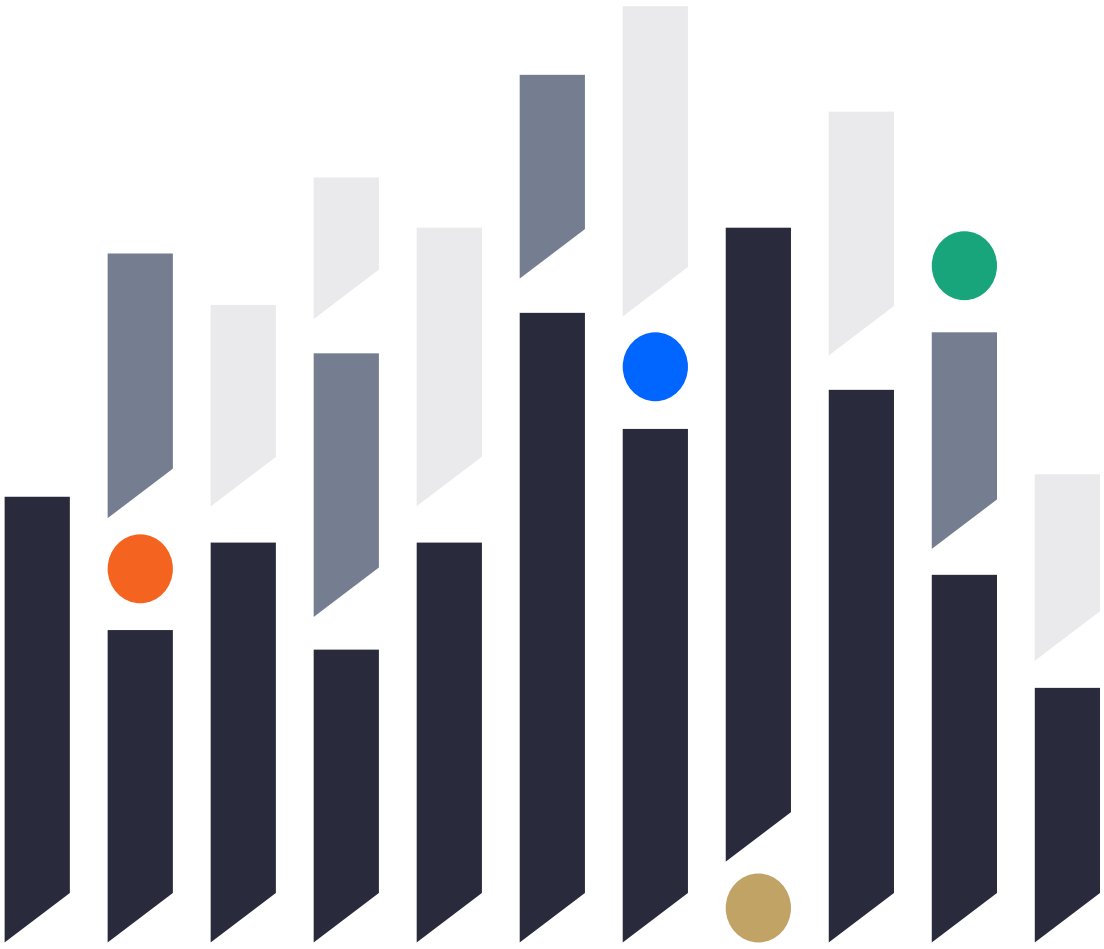
UNIVERSITY OF CAMBRIDGE
Centre for Digital Built Britain

CDBB L2C PROGRAMME

Standards landscape and information management systems



WP1 Agile Standardisation Methods for DBB

urban innovation labs

Executive summary

Standardisation practices have existing since the first industrial revolution playing a key role in interoperability and scalability of new products and services across every sector and industry. As we enter the 4th industrial revolution the speed of development of new technologies has increased dramatically and so consensus and standards to scale good solutions requires a new agility never needed before. In particular, looking at the complex market dynamic in the Digital Built Britain landscape, the role of interoperability has never been more prominent, and CDBB is in a position to support this across a number of industries which have a strong link to the built environment and its performance.

The role of National and International Standardisation Bodies, is to capture the knowledge developed by industry to deliver new products or processes that have sufficient market acceptance and consensus and that will have a long-term benefit to the market by enabling a consistent and harmonised approach to doing things. This in turn plays a key role in standards adoption, as standards are in the most part voluntary. This is essential to market adoption of new products and services too, as standards provide assurance of quality. However, these activities are not agile in nature. Standardisation Bodies have developed a symbiotic relationship across many different industries with organisations that can work closer with industry to address the needs of fast paced development. These organisations, which we have loosely called 'Industry Bodies' and whose shape, size and approach varies depending on the industry and the challenges the seek out to address. They have a key role to work closely with their members to address the technical challenges facing their industries and promote innovation through collaboration to solve common challenges. They are able to move quicker and mobilise experts in a more meaningful way, to speed up the rate of innovation.

The key learnings from this workpackage can be summarised:

- Standardisation bodies and industry bodies play very distinct roles.
- The pace of innovation and development cannot be set by the standardisation bodies, but they can support the development of innovation by identifying the gaps in the current established practices, work with researchers and academics to establish foundational standards from the early stages of research and then develop the standards required for market growth in a timely manner.
- The types of publications that are produced by standardisation bodies and industry groups alike need to be thoroughly understood and tested with users to ensure that the tools provided help the user rather than inundating them with thousands of standards. Industry bodies must continue to work close with industry members to understand their challenges, elevate them and mobilise experts and innovators to find suitable solutions.
- The relationship between these two groups needs to be symbiotic. The two roles are essential to innovation as well as diffusion across the market to improve best practice.

The landscape of Digital Built Britain already comprises of a number of Standardisation Bodies and Industry bodies that are addressing the challenges that smart cities and smart infrastructure pose to the built environment and how assets are managed for a better outcome. However, a lot of the effort is duplicated and in many cases to the detriment of interoperability and the common goal of a more efficient built environment.

The Centre for Digital Built Britain plays an important role in providing leadership to push the boundaries of the status quo and should consider the role it is able to play in the co-ordination of several industries through the better management of the built environment to maximise the value it offers.

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1 Introduction

Standardisation originated in the first Industrial Revolution, when Henry Maudslay developed the original screw-turning lathe in 1800. This was followed in 1841, when Joseph Whitworth defined a thread form, thus becoming the first unofficial national standard adopted internationally. By the end of the 19th century the lack of interoperability was becoming a constraining factor on growth. To address this, the UK National Standards body was formed in 1901 called The Engineering Standards Committee, evolving to the British Standards Institute. Other nations followed in rapid succession with Germany in 1917 and the USA in 1918.

In 1906, the International Electrotechnical Committee (IEC) defined the foundation on which our electrical and informatics systems are constructed. It is a fitting reminder that as we enter the fourth Industrial revolution, the need to allow different systems to interoperate and integrate independent of the creator is as important today as it was back then, but the number of interfaces needed to manage the ambition of CDBB is much greater.

Standards facilitate every day life. They increase safety and can be used to rationalise operations. Standardisation ensures that products, services and methods are appropriate for their intended use. It ensures that products and systems are compatible and interoperable.[1] In essence, a standard is an agreed way of doing something. It could be about making a product, managing a process, delivering a service or supplying materials – standards can cover a huge range of activities, either undertaken by organisations or used by their customers.[2]

The benefits of standards are widely recognised. Standards are essential for commercial activities; to improve clarity and transparency in communication and ensure safety for the consumer, the client and the supplier alike. Standards improve market access and increase competitiveness and efficiency. They facilitate trade, particularly in reducing technical barriers and artificial obstacles to international trade and providing a framework for achieving economies, efficiencies and interoperability. Standards aid better relationships and communication in the supply chain and improve interoperability between new and existing products. Standards play an important role to improve consumer safety, enhancing consumer protection and confidence. Finally, standards play a key role in supporting public policy objectives and, where appropriate, offering effective alternatives to regulation.[3] [4]

Consider what the world would be like without standards: [4]

- Products might not work as expected.
- They may be of inferior quality.
- They may be incompatible with other equipment – in fact they may not even connect with them.
- In extreme cases, non-standardised products may be dangerous.
- Customers would be restricted to one manufacturer or supplier.
- Manufacturers would be obliged to invent their own individual solutions to even the simplest needs, with limited opportunity to compete with others.

Society needs standards!

[1] https://www.sfs.fi/en/publications_and_services/getting_to_know_standards/why_do_we_need_standards

[2] https://www.bsigroup.com/en-GB/standards/...standards/standards-and-small-business/

[3] https://ec.europa.eu/growth/single-market/european-standards/policy/benefits_en

[4] http://www.etsi.org/standards/why-we-need-standards

1.1 Purpose

The purpose of this document is to review the different approaches to the development of standards through literature review and dialogue, assess how these could be applied to the scope of the Centre for Digital Built Britain (CDBB) and provide recommendations for how CDBB could consider approaching future standards development.

1.2 Methodology

This document will establish the purpose of standards and their role within the project scope. A literature review will summarise the different approaches taken by the major standards organisations, both national and based in industry, to highlight areas of commonality and difference. It will include the observations of leading thinkers in this space taken from structured interviews to highlight their experiences, and reflect on how the mission of CDBB may impact on existing approaches.

2 Background

2.1 The relationship between Standards and Regulation

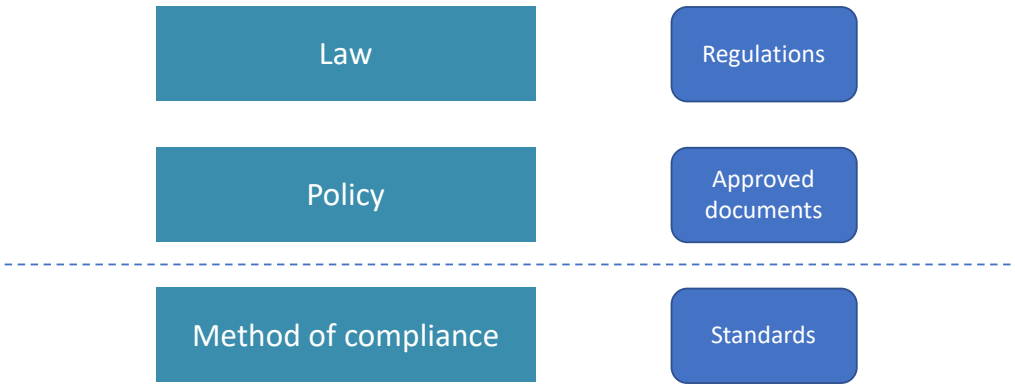

Figure 1 – relationship between Standards, Policy and Regulation

While this paper does not cover the relationship between standards and regulation in depth, it is worth noting that these are clearly distinct. There is a natural hierarchy between standards, policy and law.

Legal requirements of compliance are enshrined in enacted regulation that must be complied with. Failure to comply with a regulation is a legal infringement is dealt with through the judiciary. With a regulation being the enactment of a policy.

Government develops policy which describes the position the elected representative takes on a particular subject. As previously mentioned, when enacted this becomes regulation and is a legal position. However, a policy is a position that is encouraged but not binding.

Standards are developed by consensus and a critical mass needs to be reached for the standards to be considered best practice and for the market to be incentivised to adopt them. Standards are voluntary unless they are requirement set out by the client or governing authority. The example of

the BIM standards adoption is clearly an example of this. The largest client for infrastructure in the UK simply mandated that all their projects needed to be compliant with BS1192 and a large number of providers adopted these practices, pushing adoption to critical mass and precipitating a big change in how assets were designed and delivered. No consensus is necessary to be able to establish a regulation. The difference between a standard and a technical regulation lies in compliance: while conformity with standards is voluntary, technical regulations are, by nature, mandatory. Standards are not the same as regulations, and following a standard does not guarantee adherence to the relevant laws. In fact, because legislation can change within the lifetime of the standard, they rarely cite the law.

2.2 Economic impact of standards

"Standards are codified knowledge. They express the work and experience of generations. They define how technologies, interfaces and products must be made in order to work properly and fit together. Whereas many companies play an active role in designing standards and in this way improve their market opportunities, scientists are not adequately represented on standards committees. Yet early involvement by researchers in the standardisation process is crucial if new technologies are to succeed in the market." [5]

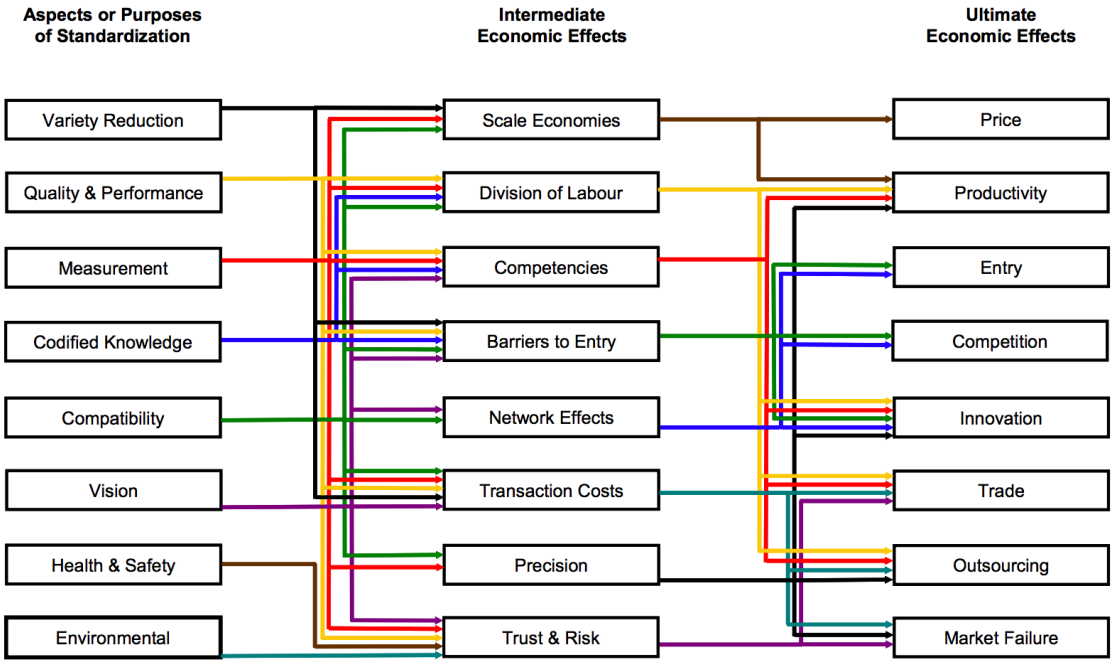

Figure 1 - Model of economic effects of standardisation [6]

Figure 1 summarises the relationship between economic effects and the different reasons for developing standards. This categorisation of the 'purposes of standards' illustrates the differing

5 http://www.lemmens.de/medien/periodika/wissenschaftsmanagement-special/wissenschaftsmanagement-special

6 THE ECONOMICS OF STANDARDISATION, HTTP://CITESEERX.IST.PSU.EDU/VIEWDOC/DOWNLOAD?DOI=10.1.1.618.5922&REP=REP1&TYPE=PDF

scope of standardisation. Understanding the current market barriers is essential to contextualise the action required for the fulfilment of the CDBB mission, given its complexity in scale and scope. However, all aspects of standardisation are important and necessary to achieve a fully operational state and therefore realise the latent value contained in the built environment. A key aspect absent in this model is the socio-economic drivers and how these can be expressed in terms of traditional economic terms.

In the vision for CDBB, what is the role of the Centre versus the government departments? Whose role is it to coordinate action on the standards that are developed and at what rate? The challenge to coordinate market development in Network industries is notably complex, and network operators and regulators therefore play a key role in supporting this function.

2.3 Catalyst effect of standards

2.3.1 Market barriers

Standards support lowering market barriers to new entrants, which in turn promotes competition. While this may seem counter to the variety reduction, these two features are mutually supportive. Gaining sufficient standardisation, through the description of the functionality and performance requirements of products and services, supports scalability and interoperability and safeguards against extensive lock-in from incumbent providers. Standards also help in reducing the time to market for new technologies.

2.3.2 Innovation in Network Industries

In these industries, compatibility standards are the basis for fostering innovation. They support the acceleration of diffusion of innovation (for example, GSM). Addressing demand is important to support adoption and establish new or improved practices made possible by the introduction of new technologies.

Innovation in downstream and upstream markets can also be enabled through the implementation of platform standards[7] and their careful rollout. In the case of CDBB, it looks at multiple markets and industries coalescing in a complex value network with the most notable example being the W3C standards.

2.3.3 Consumer trust

Standards must reflect user needs from the end user or consumer of a product, to every intermediate user providing a service in the supply chain. Standards also set out minimum requirements for environmental impact, social impact and health and safety, thus promoting trust in the user and consumer. This also plays an important role in connection with policy at both a local and national level.

2.4 Discussion

While the benefits are many, it is important to note that as consensus is reached, standards represent the lowest denominator of all actors involved. This poses a challenge relevant to CDBB. As

[7] https://www.w3.org/standards/

the scope of CDBB increases, the consensus for compatibility will have an impact on the value of standards produced. Furthermore, developing specific and technical standards for all the users and stakeholders will not only duplicate existing activities but would quickly stifle the innovation potential of applying the knowledge and learnings from several sectors to a common challenge. Instead, focusing the effort in defining what the asset is for through defined functionality and performance, would be a more novel approach for leading academia and industry to innovate, while assisting this through the description of needs to fulfil economic and societal requirements.

The CDBB, in connection with HMG, need to clarify the role of the Centre in regard to its market making function and in accordance how standards (as well as research, industry engagement and Government policy) feature in this. In doing so, it should articulate clearly how it is plans to address the market barriers for a future Digital Built Britain. The role standards play as enablers is important and should be prominent.

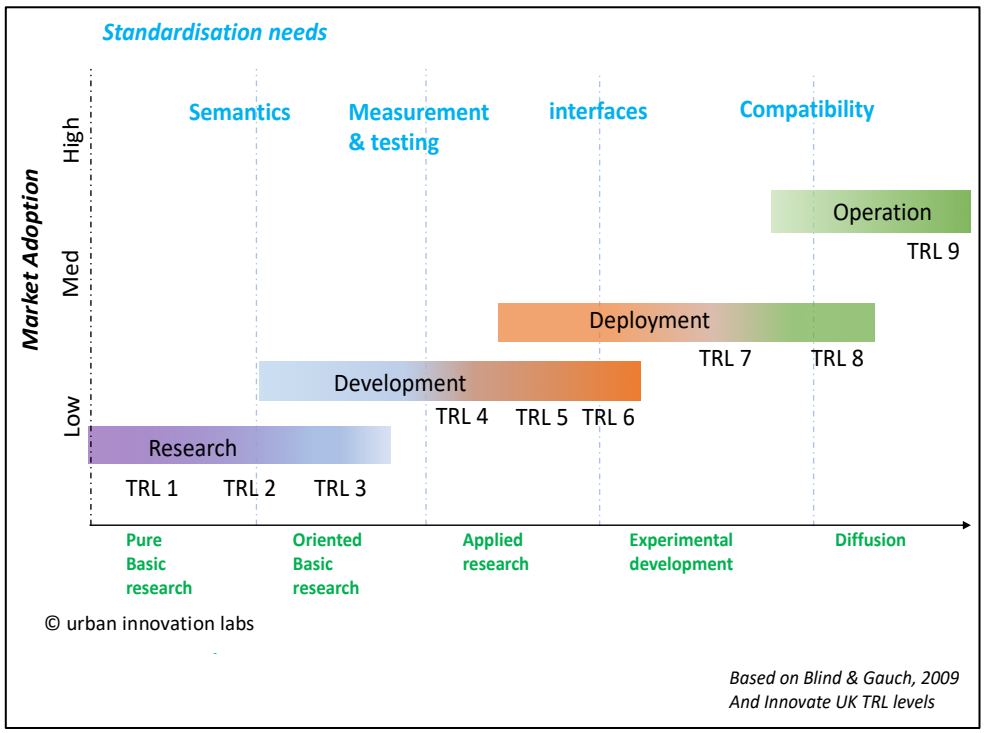

Figure 2 - innovation process and the relationship with standards

Figure 2 provides examples of the standardisation requirements from early stages of research through to market adoption and operation of new products or services. This figure also integrates the Technology Readiness Level (TRL) to provide a connection to commonly understood levels of development of technology and their application. It would be anticipated that CDBB would have an array of such graphs describing the standards development for all sectors, industries and technologies, throughout the development cycle for all stages of the asset lifecycle.

The approach to manage the development of standards should be linked to core research, applied research, pilots or large-scale demonstrators in the journey to implementing these new products or processes operationally. A key enabler to deliver coordinated action across the CDBB arena will be

the agility in the way knowledge is captured and translated into iterative releases of guidance, throughout all communities of practice.

In the following section we explore the different types of bodies that currently support the development of standards: National Standards Bodies (NSB) and Industry membership bodies. Each of these organisations is able to fulfil distinct functions. Often, Industry Bodies are able to respond to the needs of the market faster, while NSB have a stronger focus in cementing the knowledge of practices developed by those spearheading new technologies.

We can learn from the symbiotic relationship between established Industry groups and their relationship with standards bodies. The CDBB should foster the agility to identify and support the market in the early development of potential solutions, while maintaining a close working relationship to drive the development of de jure[8] standards by the NSB. This will turn support the diffusion of knowledge and market growth.

3 Standardisation bodies and methodologies

Standards are created to formalise industry best practice and provide a common interface between different actors in a value chain. Standards, in their majority, are specific and technical to support experts to deliver products and services accurately and safely. There is an emergence of how standards, particularly with regard to information technology, are providing a framework in order to integrate large and complex systems.

The rate of innovation in technologies and their adoption into mainstream service delivery is unprecedented. As such, long cycles for standardisation can stifle the rate at which products and services are developed in some cases. Using traditional approaches consensus needs to be achieved to create standards and the processes to reach such consensus usually take a minimum of 9-12 months for a Publically Available Specification (PAS), between 12-24 months for a British Standard (BS) and up to 48 months for an ISO standard.

Standards are developed when a group of parties identify the need to agree a way of doing something. This group is generally industrial parties who have a shared interest in reaching agreement in order to achieve a level of safety, to enable market growth, or where sponsored by a Government to support local or national policy.

There are two types of bodies that support these market needs: the National or International Standardisation bodies such as BSI, ANSI, ISO, or CEN, and Industry Membership Bodies such as W3C, BuildingSMART, Hypercat or 3GPP. These groups fulfil different roles in the standardisation process and are both necessary. Industry Membership Bodies are cooperatives that focus at developing solutions to key technical challenges facing their particular industry, and in doing so they often develop what we call ‘de-facto’ standards. These are usually technical specifications that enable organisations to overcome technical barriers. The work of these industry bodies is often targeting emergent challenges for which consensus is not yet achieved and rely on their members to work together to develop potential solutions. When sufficient consensus exists, and the new practices have been proven to have potentially wide benefits if standardised, standardisation bodies are approached to formalise the knowledge and best practice in ‘de jure’ standards.

[8] A technology, method or product that has been officially endorsed for a given application.

The bulk of standards rely on a majority consensus. For example, private standards can be developed for internal use by a company or group of companies without wider consensus. Standards are voluntary and therefore don't need to be applied unless the client, for example, mandates it. In the case of BIM, the client, HM Government mandated the use of a particular standard thus precipitating its adoption. However, not all clients require BS 1192 to be abided to. This raises another key aspect of standard development. De jure standards are often developed once there is sufficient consensus in the market for a particular set of rules to be formalised. The role that the Industry Membership Bodies play in advocating for the adoption of new ways of working goes a long way to ensure that the standards developed are accepted and adopted. The need for Standardisation Bodies to work closely with industry bodies is absolutely imperative, for the benefit of industry itself.

There are over 20 bodies that release de jure standards and the manner in which they develop standards is consistent. Some of the most prominent de jure bodies of relevance are:

- IEEE-SA — IEEE Standards Association
- IETF — Internet Engineering Task Force
- ISO — International Organization for Standardization
- ITU — The International Telecommunication Union
- OGC — Open Geospatial Consortium
- CEN — European Committee for Standardization
- CENELEC — European Committee for Electrotechnical
- ETSI — European Telecommunications Standards Institute
- ANSI – American National Standard Institute
- BSI – British Standards Institute

In the UK, the British Standards Institution (BSI) is formally recognised as the National Standards Body (NSB). It develops and publishes over 2,000 standards each year, the majority carrying the formal status of a British Standard. Most are based on European or international standards to which UK interests make a major contribution. A small proportion of its output comprises standardisation documents that are developed wholly within the UK. Amongst these is a category termed PAS (Publically Accessible Specification).

A similar process is followed by most National and International standardisation bodies and includes four main stages:

(i) identifying the topic and ensuring that this is not already part of another current or developing standard,
(ii) appointing a technical writer or convener (depending on the organisation) and creating an experienced and relevant technical committee to take part in the development,
(iii) drafting the standard, and
(iv) reaching consensus as part of a multi-stakeholder consultation process. [9] [10] [11] [12].

[9] https://www.iso.org/developing-standards.html
[10] https://www.bsigroup.com/Documents/about-bsi/NSB/BSI-pocket-guide-to-standards-development-UK-EN.pdf

The next sections explore some aspects of the standards development process and reviews the range of deliverables and publications that these bodies produce.

3.1 Standardisation Bodies approaches

This section describes the approach taken by organisations such as BSI, CEN and ISO, which follow similar approaches for the development of standards and have similar governance. It is worthy of note that other standards bodies such as CEN and ETSI (at European level), UNE (Spain) or DIN (in Germany) follow very similar approaches informed by the genesis of the organisations.

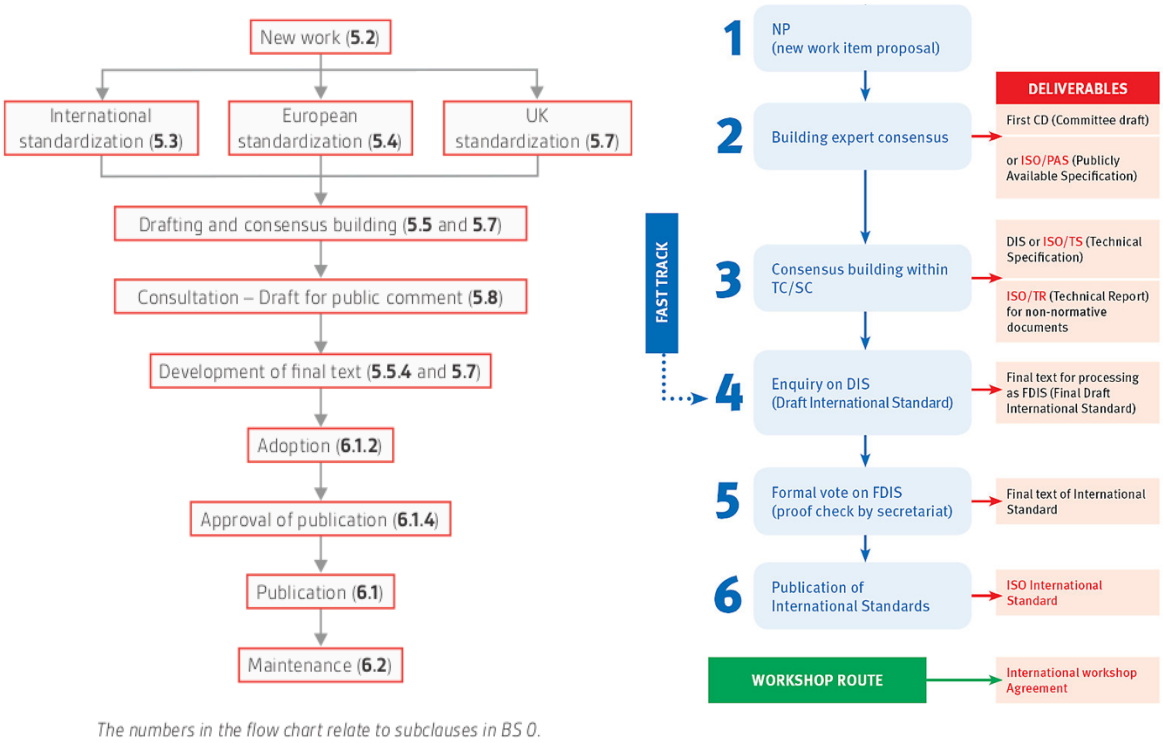

Figure 3 - Process of development in BSI (left hand flowchart) and ISO (right hand flow chart)

The flowcharts in Figure 3 illustrate the development process followed by the two organisations, BSI and ISO. In the case of BSI's processes, a key decision as to the route of the standard is made up front: whether the standard in question needs to be developed at International, European or National level. There are many levers that affect this decision. Global influence is important when looking to export knowledge and expertise, and internationalisation of standards supports the adoption of products and services internationally. The UK is at the forefront of a number of industries and has an important influence in international standards. Indeed, BSI represents the UK interests in the standards landscape internationally. The process thereafter is nearly the same: a strong focus on consensus and public consultation and finally, formal adoption.

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[11] https://en.wikipedia.org/wiki/3GPP

[12] https://www.buildingsmart.org/standards/standards-process/

3.2 Case study – comparison between UK and EU practices

There are some differences in the approach taken between the UK and other European standards. Figure 4 describes some key differences in the way that standards are developed by different NSBs, largely due to a different culture and funding model.

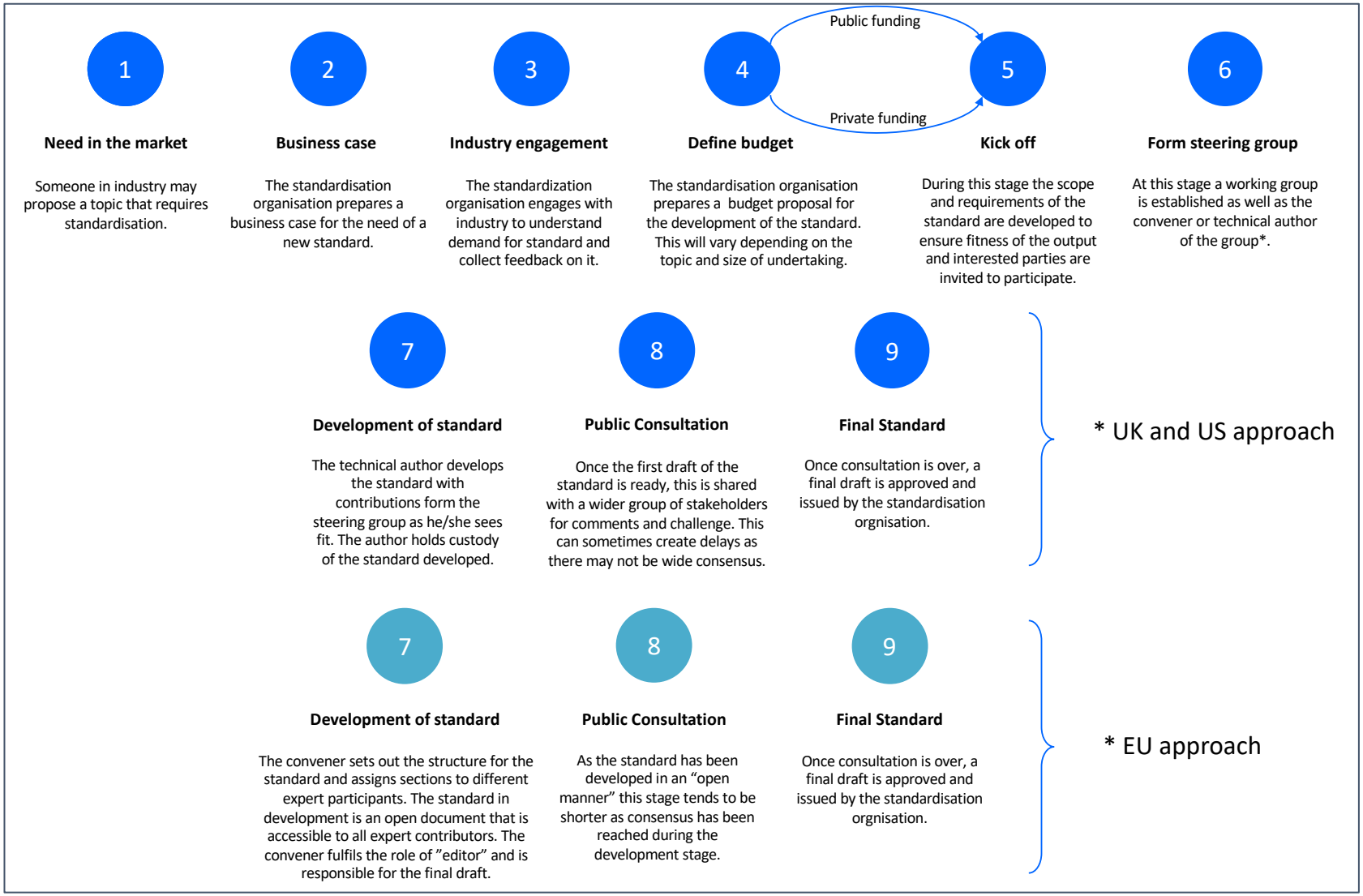

Figure 4 - comparison between UK and EU practices

3.2.1 Cultural requirements

The UK/USA approach relieson a technical expert appointed to write the standard or specification. The technical writer will engage a working group in the development process, but they alone are in charge of writing the document. This document is then circulated for comments and amended until all members are in agreement. The technical writer also has the power to veto changes.

The content of the final draft is then subjected to consultation. In order to develop standards, sufficient advocacy is required. In the case of the UK/USA approach, there is a risk that advocacy is not sufficiently developed from the start of the process leading to delays in the release of the final document. Recent experience in the development of one of the Smart Cities standards revealed the challenges to reach consensus, delaying the publication by a year.

In the EU approach, rather than a technical writer, a convenor is appointed. The role of the convenor is highly regarded in European standardisation circles and a coveted honour. The convenor becomes the 'editor' of the document, and has ultimate responsibility for its development and completion, but any number of members can be involved in writing the document, and in fact often the convenor will assign different chapters to different members. When in development, the standard is accessible to members only, and only available more widely once it is officially published.

It is arguable that this approach builds greater advocacy for the product right from the start, as a greater number of people and organisations are invested in its development. However, this can be an expensive process for member organisations to participate, but the concept of a more open document being developed and written by a number of people simultaneously and then edited by the convenor, evokes a greater sense of consensus in the final product. The differences in practice are subtle, but impactful.

> "Writing a standard is like writing a book, it needs to make sense within chapter but also as a whole. The Convener in the EU approach is the editor of the book, making sure all the chapters are right and tell a consistent story throughout". Dr Lluisa Marsal

3.2.2 Funding models

Pay to play

This approach is adopted by many of the industry membership groups, where an annual fee is required to take part in the development of the specifications. In a similar manner, de jure standards bodies can also choose to fund their activities through a membership model. While the final standard is offered to everyone (whether for free or for a fee) only members are able to take part in the development, and therefore influence the process.

Pay per content: option 1

In this model, each standard commissioned is funded individually, and its cost is estimated based on a range of factors including the breadth of scope, amount of research that is likely to be required, level of engagement required with the market and current level of consensus. The sponsoring organisations share the cost of developing the standard to cover the cost to the NSB and that of the technical author. The document produced is then available to all for a fee. This is the approach adopted by BSI.

Pay per content: option 2

This model is generally used for PAS development. Here a sponsor is required, whether a sole sponsor or a group of sponsoring organisations. BSI are given the responsibility to coordinate a neutral working group to work alongside the technical author, rather than having only the sponsoring organisations involved. This hybrid model still requires the investment of interested parties but slightly democratises the process.

Regardless of the model, investment, whether private or public, is required to support the standardisation process. This calls upon government and industry to invest actively in this as part of their duty to develop and advance respective industries. While it can provide good publicity, vested interests can get in the way and therefore transparency is essential for the standards to be trusted by all.

A standard process to encourage trust, accountability, but also open innovation and market growth could feature the following characteristics:

- Where a technical author is required, there is a competitive bid.
- Document is open to everyone in the technical working group or community.
- The process is open, live, accessible and transparent.
- More than one person is part of the writing process.
- Process has a greater level of participation from the start, ensuring a wider range of stakeholders are included in the development of each standard.

Some or all of the above approaches are followed by many of the industry standard groups, and the principles of the Open Stand[13] are followed by many organisations such as W3C. When CDBB considers how it will engage with industry and address technical challenges as a community, the above features should be included in the governance of the communities.

3.3 Industry Cooperative approaches

In emerging markets, especially when it comes to technology, the National Standards Bodies are not perceived by industry as providing the mechanisms to support the outcomes they need and therefore different approaches are adopted. In practice, this is due to the nature of the work that NSBs carry out, which can be misunderstood. NSBs are able to produce standards as a result of consensus but this is impossible during the early development of emergent technologies.

For decades industry bodies have coordinated themselves In order to address this gap and addressed challenges in the industry through collaboration and cooperation. As a result standards have been developed with sufficiently established solutions and consensus.

Four such organisations have been selected to illustrate this: buildingSMART, HyperCat, 3GPP and W3C. A long list of all such organisation can be found in Appendix A.

3.3.1 BuildingSMART

In 1995, Autodesk organized a private alliance of 12 companies to prove the benefits of interoperability between the disparate software programmes used in the building industry. The

[13] https://open-stand.org/about-us/principles/

companies belonged to the AEC industries and were willing to invest in the future of the Building Industry. After a year, the group concluded that interoperability was viable and had great commercial potential. In addition, the alliance believed that any standards for this interoperability must be open and international. It was initially named the International Alliance for Interoperability, changing its name in 2008, to buildingSMART to better reflect its mission.

buildingSMART is a chapter membership organisation, where chapters are national membership organisations whose purpose is to promote and drive forward the active use of open data standards in a particular territory. Chapters aspire, and are expected, to play a leading role in influencing industry and government strategy for the adoption of open standards within their country of operation. Furthermore, they are expected to build user engagement through the relevant supply chains, provide support and training where required and identify standards and compliance requirements. Individuals and corporate entities will join through the national chapter in their country. Chapter members are represented in buildingSMART international programmes collectively through chapter voting rights.

Industry Foundation Class (IFC) standards were the first to be developed by buildingSMART and exist for sharing and exchanging BIM data across different software. buildingSMART continues to update the IFC standard and is developing a range of other standards to serve the building and infrastructure industries.

The standardisation process followed by buildingSMART is formal process for the development of consensus-based standards and solutions and is well documented in their website[14]. The needs identification process is strongly rooted in the strong engagement with industry and is widely promoted across the different regions and chapters. The standards are developed through the following process:

(i) Initiation: standards proposals are developed which clearly identify the user need and standard concept. This is a document with a business case, work plan and stakeholder support plan which addresses the following:
   a. Formal support from at least one chapter and one member.
   b. Formal consortium and project lead appointed.
   c. Expert panel and review governance established.
   d. Commitment to the bSI process and IP rules.

(ii) Solution development comprises as follows:
   a. The consortium follows the agreed work scope and bSI's programme process. Sponsoring rooms and groups oversee the execution of the standards projects.
   b. As the solution is developed, sufficient reviews must take place for user testing, commercial requirements, technical architecture and implementation requirements.
   c. The standards are the outputs from the solution development work. A draft standard is reviewed by the Committee Executive.

(iii) Approval. This will vary according to the type and level of standard maturity desired:
   a. Standards wishing to become ISO will follow the ISO process.
   b. Standards wishing to achieve bSI status will follow the buildingSMART Notification and Voting procedures.

[14] https://www.buildingsmart.org/standards/standards-process/

c. Standards can follow both routes simultaneously.

buildingSMART has partnerships with ISO and OGC, where it chairs technical subcommittees dealing with the IFC standards family and supports the route for buildingSMART standards towards ISO standardisation.

3.3.2 Hypercat

Hypercat is a global alliance and standard, driving secure and interoperable IoT for industry in cities. The Hypercat Alliance aims to create an inclusive one-stop shop of best practice IoT implementation through the sharing of knowledge of processes and applications. Hypercat has more that 50 partners engaged in their activities and has developed various use cases for the application of the Hypercat standard (PAS 212) including Smart Mobility, Smart Neighbourhoods, Smart Water and Smart highways.

Hypercat was born out of a Technology Strategy Board innovation project (now known as Innovate UK), funded to deliver early proof of concept of data interoperability to enable the M2M Internet of Things[15]. About 40 partners formed this consortium, seeking to drive innovation for small and medium enterprise, rather than only large tech companies. The work was based on a use case approach, and different organisations in the project ecosystem trialled Hypercat in their individual use cases, sharing successes and challenges to overcome with the consortium and the wider community.

It is extremely simple, described by one participant as 'the most that 40 companies could agree on'[16] with a strong security model. A set of best practices and tools is currently being developed. The Hypercat alliance recently commissioned a PAS by BSI, formalising the work developed by the project into PAS 212. This has been adopted in Australia as the go to standard for IoT and smart cities for interoperability.

While Hypercat is still very young compared to other more established organisations, the nature of the challenge they are tackling requires the alliance to be agile in how they address needs. A good way to do this is to take a use case approach, enabling testing of the core technologies in different contexts while better understanding the market needs for each use case.

The long term plans of the Alliance or relevant standards they will support is not clear, and therefore difficult to judge the longevity and sustainability of the standards that they have commissioned. Hypercat and its members would benefit from a clear roadmap, aligned to other larger organisations addressing IoT in cities (ITU for example) and with a clear development plan.

The activities of Hypercat should be considered by CDBB, due to their importance to interoperability for devices in the UK.

3.3.3 The 3rd Generation Partnership Project (3GPP)

The 3GPP is a collaboration between groups of telecommunication standards associations, known as the Organisation Partners. 3GPP produces Technical Specifications, to be transposed by relevant Standardisation Bodies (Organizational Partners) into appropriate deliverables (for example,

[15] http://www.itpro.co.uk/strategy/22571/m2m-internet-of-things-innovation-pushed-by-uk-technology-strategy-board

[16] http://www.hypercat.io/standard.html

standards). 3GPP develops technical specifications (TS) that support the development of standards by the right groups, but are often misleadingly thought of as standards in their own right.

Any organisation can become a member and take part in the development activities, however, the process of membership is not simple and classification is based on the Electronics Communication Related Turnover (ECRT[17]). 3GPP has strong links to a number of international standardisation bodies, including ITU, CEN, and CENELEC. The seven 3GPP Organizational Partners - from Asia, Europe and North America - determine the general policy and strategy of 3GPP and perform the following tasks:

- Approval and maintenance of the 3GPP scope.
- Maintenance of the Partnership Project Description.
- Taking decisions on the creation or cessation of Technical Specification Groups, and approving their scope and terms of reference.
- Approval of Organisational Partner funding requirements.
- Allocation of human and financial resources provided by the Organisational Partners to the Project Co-ordination Group.
- Acting as a body of appeal on procedural matters referred to them.

The initial scope of 3GPP was to make globally applicable 3G mobile phone system specifications based on GSM specifications within the scope of the International Mobile Telecommunications-2000 project of the ITU. This has since expanded to include 4G and 5G.

3GPP standards are structured as releases. Each release affords a different functionality, and incorporates hundreds of individual standards documents, each of which may have been through a number of revisions. The management of releases follow principles from 'agile methodologies'. The releases assembled are available freely on the 3GPP website, and there can be as many as 4 releases annually. These cover the Radio network and Core network as well as Cryptographic aspects.[18].

3GPP also produces guidance documents and releases global innovation webinars where member organisations discuss relevant topic or present some of their latest achievements in mobile technologies. The 3GPP Mobile Competence Centre, based at the ITU, supports all the activities of 3GPP.

The 3GPP follow a three-stage methodology as defined in ITU-T Recommendation:

- Stage 1 specifications define the service requirements from the user point of view.
- Stage 2 specifications define an architecture to support the service requirements.
- Stage 3 specifications define an implementation of the architecture by specifying detailed protocols.

There is a symbiotic relationship between 3GPP and the standardisation bodies relevant to mobile technologies. 3GPP as an organisation can be more agile in identifying and describing the requirements for new levels of functionality, developing the solutions that can address this

[17] http://www.etsi.org/membership/fees/ecrt-definition

[18] http://www.3gpp.org/news-events/3gpp-news/1937-5g_description

functionality and facilitating the standardisation process, through the provision of tested technologies and solutions.

3.3.4 W3C

In 1994, Tim Berners-Lee, director of W3C and inventor of the Internet, formally established the World Wide Web Consortium (W3C) with support from MIT, INRIA, DARPA and the European Commission with a mandate to oversee development of common web protocols and promote web interoperability. With the Internet open and free for all to use, Berners-Lee wanted to ensure that the continuous development of his invention was done in the same way.

By producing standards that could support wide adoption, and having consulted with organisations like IETF to safeguard the interest of this invention, it became clear that the technology was nascent, and the Standardisation Body was not able to effectively create standards based on consensus for the Internet at that time. In this way, W3C was created to ensure that the development of the technology continued to move forward in a coordinated way, ensuring an open and fair development strategy, with enough consensus across the market.

W3C is a prime example of industry coming together for the greater good. The consortium has 488 active member organisations[19] . The annual membership, open to organisations not individuals, is mindful of an organisation's status (small versus large enterprise, not for profits or government organisations) creating a very heterogeneous membership body. The revenue model for W3C incudes member dues, research grants, other sources of private and public funding and sponsorships and donations.

Most W3C work revolves around the standardisation of Web technologies. To accomplish this work, W3C follows processes[20] that promote the development of high-quality standards based on community consensus; an introduction to the W3C Process gives a sense of how W3C gets work done. All stakeholders can have a voice in the development of W3C standards, including members large and small, as well as the public. W3C processes promote fairness, responsiveness, and progress: all facets of the W3C mission.

The output of the process is the recommendations that W3C publishes and are considered Web standards. The new versions of the standards are open to all members whilst in development but not the rest of the world. The W3C finished documents are shared openly once they have been approved through the committee governance of W3C. Much like 3GPP, the W3C documents are developed in 'releases' and a large community of members are involved in the process of development and review.

W3C follows open standards principles[21], and collaborates closely with international standards bodies to ensure the right connections are made and interoperability is achieved.

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[19] https://www.w3.org/Consortium/Member/List

[20] https://www.w3.org/2018/Process-20180201/

[21] https://open-stand.org/about-us/principles/

Perhaps as important as the development of these standards is the support and leadership provided to industry to continue to push the limits and innovate in the sector. The vision of W3C, 'One Web', succinctly sets out the direction for all who see the benefits in contributing to this. In setting out their mission, W3C have provided the design principles that guide their work:

- **Web for All**: the social value of the Web is that it enables human communication, commerce and opportunities to share knowledge. W3C wants to make these available to all people regardless of hardware, software, network infrastructure, language, culture, geographic location or physical or mental ability.
- **Web on Everything**: the web should be accessible form any device, mobile phones, smart phones, television systems, kiosks, domestic appliances and more.

While the magnitude of the task is ever growing, W3C and its communities work together to achieve new levels of functionality affording the Web new capabilities all the time. It is this leadership and vision that drives forward the activities and culture of this community as much as the potential economic upside of these advancements.

It can be argued that W3C is a great example of a self-organising, consensus led, standardisation body, addressing the particular challenges creating barriers for growth and innovation. It works with all members to ensure that the pace of development is fast enough to enable new innovations, but not too fast that it leaves a big part of the market behind. It has only been 4 years since the HTLM5 standard was published yet many rumour that HTML6 is just around the corner, marketed to players trying to develop new applications needing this new release of the HTML code.

However, W3C has a clear and specific scope focused on a particular technology and servicing the needs of its direct industry. (Albeit almost everyone else derives value from this whether it is as a result of having a website to advertise products, or create interactive applications that support workers on the go.)

Digital Built Britain's vision, in its current form, seems so much more complex than that of W3C and encompasses as many stakeholders, if not more. It also deals with industries and markets that are extremely diverse and speak different languages. The work of W3C spans from inception of a new technology or innovation, to development of solutions, to supporting the adoption of this in the market. It is important for Digital Built Britain, like W3C, to hone into the key aspects of information of the built environment that it is seeking to address and engage with the market in a meaningful way.

3.4 Types of publications

Whether from a NSB or Industry membership group, the documents produced will generally fit under the following categories: standards, technical specifications or reports, PAS, specification workshops or guides. Table 1 provides a summary of the main types of publications issued by standards bodies. Each of these publications responds to different needs and are developed at different rates and speeds.

Publication type	Description
Standards	A Standard provides rules, guidelines or characteristics for activities or for their results, aimed at achieving the optimum degree of order in a given context. It can take many forms. Apart from product standards, other examples include: test methods, codes of practice, guideline standards and management systems standards.
Technical Specifications	A Technical Specification addresses work still under technical development, or where it is believed that there will be a future, but not immediate, possibility of agreement on an International Standard. A Technical Specification is published for immediate use, but also provides a means to obtain feedback. The aim is that it will eventually be transformed and republished as an International Standard.
Technical Reports	A Technical Report contains information of a different kind from that of the previous two publications. It may include data obtained from a survey, for example, or from an informative report, or information of the perceived 'state of the art'.
Publicly Available Specification (PAS)	A Publicly Available Specification is published to respond to an urgent market need, representing either the consensus of the experts within a working group, or a consensus in an organisation external to the Standards Body. As with Technical Specifications, Publicly Available Specifications are published for immediate use and also serve as a means to obtain feedback for an eventual transformation into a Standard. Publicly Available Specifications have a maximum life of six years (only 2 years for BSI PAS), after which they can be transformed into a Standard or withdrawn.
Specifications IWA	An International Workshop Agreement is a document developed outside the normal ISO committee system to enable market players to negotiate in an 'open workshop' environment. International Workshop Agreements are typically administratively supported by a member body. The published agreement includes an indication of the participating organisations involved in its development. An International Workshop Agreement has a maximum lifespan of six years, after which it can be either transformed into another ISO deliverable or is automatically withdrawn.
Guidelines	They help readers understand more about the main areas where standards add value. Some Guides talk about how and why, standards can make it work better, safer, and more efficiently.

Table 1 - Summary of publication types from standards bodies

The choice of the publication type should be assessed against the following factors:

- Time to develop.
- Responds to emergent technical and market needs.
- Enables feedback from users of the standard.
- Can be updated on an ongoing basis, with input from the practitioner community.

The impact of these factors on the different publication types is shown in Table 2

Publication type	Time to develop	Responds to emergent technical/market needs	Enables feedback from users	Can be updated on an ongoing basis
Standards	12 – 48 months	No – standards capture best practice.	Not really – standards are reviewed every 5 years.	Not really due to the long review cycles .

Technical Specifications	Depends on the subject.	Yes, these can respond to technical needs quite quickly (specially when driven by industry groups with ongoing engagement with members).	These can be reviewed more often (specially when driven by industry groups with ongoing engagement with members).	Yes, but care needs to be taken in order to ensure that these are updated at a rate that can be adopted. Forcing ongoing changes can have a detrimental effect on organisations as well as the bodies imposing the changes.
Technical Reports	Depends on the subject.	Yes, these can respond to technical needs quite quickly but often don't undergo a peer review process .	No.	No.
Publicly Available Specification (PAS)	Up to 12 months (provided consensus is reached promptly).	PASs can help capture consensus in respond to urgent technical needs (still lengthy process).	Yes, although the review cycle is 2 years.	Yes, although the review cycle is 2 years.
International Workshop Agreement[22]	Depends on the subject, but it is a relatively fast process, less than a year.	Yes, it aims at finding consensus with a number of industry players on a particular specific topic that is a common challenge.	Only as part of the process to develop it.	It is valid for 6 years and only reviewed after this period.

Table 2 - Considerations for the selection of publication type

The BSI, in the UK, develops 2 types of standards: British Standards or Publically Available Specifications. A short description of each has been provided below outlining some of their key benefits and challenges.

British Standards

British Standards and international standards are intended to represent good practice agreed by experts involved in their development and wider stakeholders through open consultation. This wider engagement seeks to provide a balanced and representative standing of committees that have the responsibility for the standards indefinitely. British Standards remain subject to systematic periodic review as to their ongoing validity.

The reliability of a British Standard rests not just on its technical accuracy and the sound judgement of those responsible for its text. There needs also to be a widely held confidence that the standard in

[22] https://www.iso.org/files/live/sites/isoorg/files/developing_standards/docs/en/iwa.pdf

question is needed in the market, and it is practical and authoritative, serving the need of the wider community. Standards cannot favour any particular party. Finally, British Standards must be consistent with Regulation and legal principles at the time of publication.

The majority of documents published as British Standards have their origin in international standards (developed by ISO and IEC) or European standards (developed by CEN and CENELEC, often in partnership with their international counterparts). The remainder are developed exclusively by BSI to meet particular needs in the UK.

International (ISO, IEC) and European (CEN, CENELEC) standardisation bodies follow a similar approach to BSI with a larger group of interested parties. Core to the approach is the principle of building consensus. With this larger group with often broader opinion, different imperatives and sometimes diverging views, this often leads to a longer and more onerous process of reaching consensus.

One of the challenges of international standards is that they need to be reduced to the least common denominator of all interested nations, and therefore become very high level. It is essential that the UK continues to have useful standards that support the implementation and conformity with high level strategic standards. British Standards development ranges between one and three years, depending on their complexity and breath of scope.

The route to international standardisation is mainly done through the National Standards Body, and therefore a close relationship with BSI is necessary to ensure the interests of the DBB agenda are advocated for internationally. However, BSI alone will not be able to develop a roadmap for development as this is the responsibility of the private sponsor, industry group or government sponsor.

> *"PAS55 was the best Asset Management standard across the world, and it was heavily diluted when it was developed as an ISO (ISO 55000). However, the US market only paid attention when it became an ISO."*
> Workshop participant

Publicly Available Specifications (PAS)

A PAS is developed in response to an identified market need; usually a request from a sponsor for a standardisation document that serves the needs of an emergent market, technology, service or public policy interest. While the process is shorter, and ensures strict development methodologies, PASs rarely come under the responsibilities of one of BSI's committees. This is summarised in Figure 5.

Figure 5 - PAS development process by BSI

PASs have an initial lifespan of 2 years, where they are monitored for their uptake and application. After

this initial period, BSI and the sponsor may decide to develop the PAS towards more formal standardisation at UK, European or international level. PASs are voluntary, a tool devised for the convenience of those who chose to use it. The PAS approach offers an effective means of quickly introducing standardisation in such cases, and for testing the value or validity of a particular approach or methodology. It can also serve as the basis for subsequent development towards more formal standardisation at UK, European or international level.

> *"In retrospective, we should have used the PAS approach to develop the first BIM standards, as it would have given us the chance to monitor over the first few years and amend it based on early feedback."*
>
> Workshop participant

PASs can provide consensus in the early stages of the development of new technologies and their application and adoption. However, they are very much client led, and may not always be developed in consonance with a strategic roadmap in line with enabling wider market creation. The journey of PAS to BS to ISO produces a very robust and tested final product. However, the road to ISO sometimes dilutes the standards as the minimum common denominator needs to be identified to reach consensus of standards that apply across the world.

Some recent examples of successful PASs developed by BSI have been the PAS212 (developed from the work done by Hypercat) or PAS 185 (developed as part of the Smart Cities standards suite) in response to security concern in the market. In both cases, the PAS was developed swiftly, based on sufficient already existing consensus. As PAS is reviewed every 2 years, it provides the opportunity to monitor adoption of it and assess whether the standard meets the needs of the public. Being openly available also enables easier access, provided the PAS is promoted across the relevant networks and some support for adoption is granted to organisation that have not been part of its development.

3.5 Discussion

In reviewing the ways in which NSB and industry collective operate, it is key to consider their mandate and the need they fulfil:

- Standards bodies exist to codify best practice and create official documents that described established practices under consensus.
- The process of standardisation is long in some cases but can be responsive to the needs of the market, and there are tools such as PASs that are better suited to solutions that have not reached full consensus but have sufficient back up.
- By standardisation supporting the wide adoption of new practices in the market, the NSB supports diffusion.
- Industry membership bodies sit closer to the market as their members are trading organisations.
- Industry membership bodies are able to have a much more rapid response to organisations' needs and coordinate action at earlier stages of development of emergent technologies to address challenges.

- Industry membership bodies, through their activities with members, develop technical specifications, which can be denoted as de facto[23] standards when widely adopted.
- Industry membership bodies work with their members to roadmap the future development of their respective industries, taking into account all the knowledge and interests of the members. However, a 'pay to play' barrier exists.

This is illustrated in Figure 6, which shows the dynamics between market players, Industry membership bodies and standards bodies. Commercial organisations are closer to the customer; they need to understand their customers to provide the solutions that offer value. In turn, Industry bodies work with these organisations to tackle challenges that arise in delivering new solutions to market. These organisations work in a much more agile manner that NSBs and are actively involved in facilitating the development of new solutions.

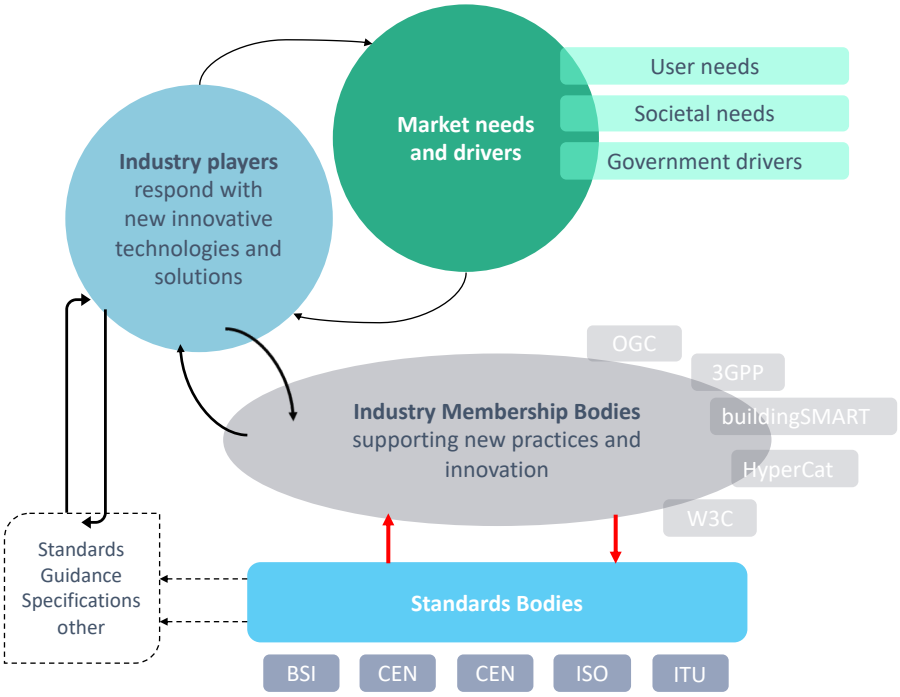

Figure 6 - Market dynamics of standards creation

NSBs need to work closely with Industry bodies to create a pipeline of new standards to help grow markets around new solutions. This relationship, represented by the red arrows in the diagram, is key to enabling an agile response to standardisation of solutions and processes that can support market growth. In addition, NSBs provide standards to organisations as a result of consensus and should monitor their use to ensure that the standard itself is performing the function sought in the first place

Digital Built Britain will need to work closely with the NSB bodies to ensure the necessary market growth in areas of innovation. However, the CDBB should also consider focussing efforts in

[23] a custom or convention that has achieved a dominant position by public acceptance or market forces

understanding the Industry bodies already taking action with market players to address the challenges they face, and then coordinate action with them.

CDBB's mission encompasses a number of industries and markets. It would be anticipated that CDBB would seek to create an umbrella alliance collaborating with existing bodies, as well as engaging with the market directly. To do this, it would need to use its renowned research capability as a lever in order to work with the market on more advanced topics. When these are market relevant, they can be commercialised at an appropriate pace that suits the market. This is shown in Figure 7:

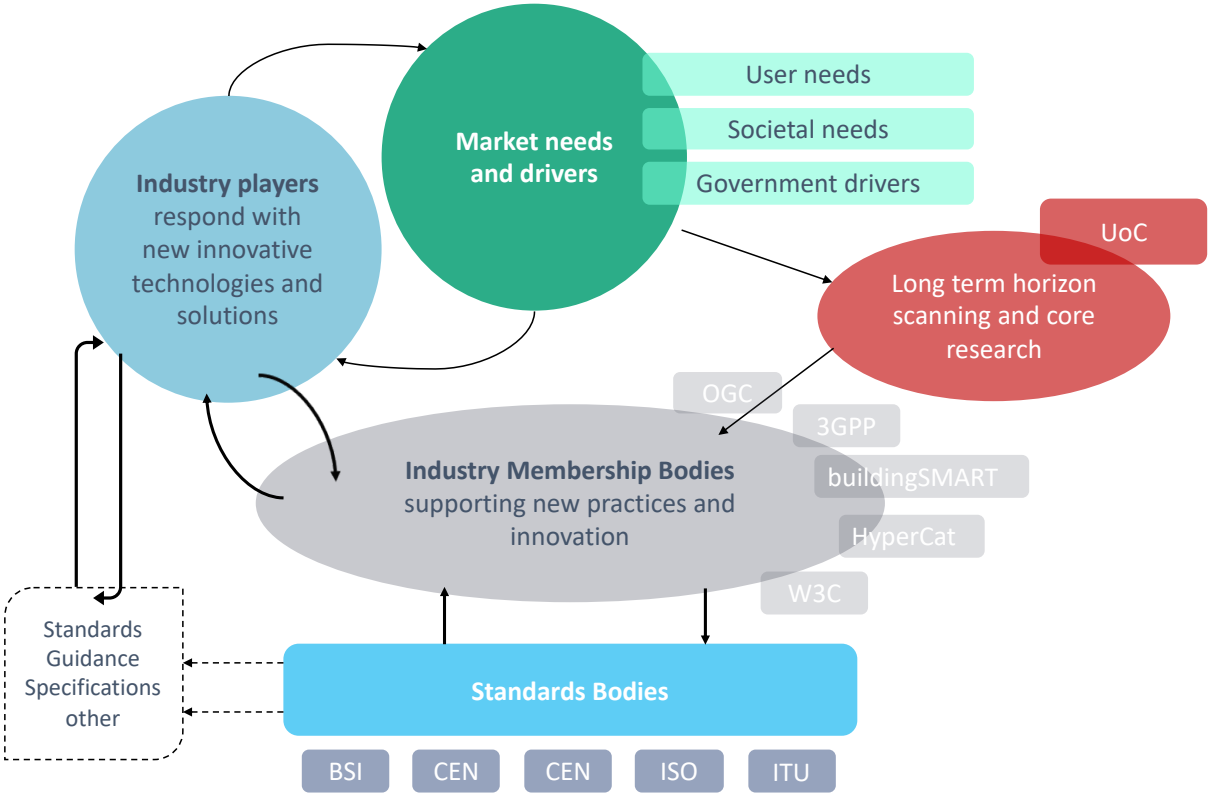

Figure 7 - Potential role of CDBB in standards creation

4 CDBB standard development requirements

One of the cornerstones of CDBB's case, is using data to enhance the natural and built environment, thereby driving up competitiveness and productivity, as well as citizen quality of life and well-being. This will require a level of interoperability and integration from a multitude of sources that are currently in silos, often unstructured and when structured, have diverse meaning. It is anticipated that this broad scope will need a variety of different approaches to standards development that are informed by the following aspects:

- What is the overall model to be established: ubiquitous, industry, country, service, user, or something else?
- What is the scale of community?

- How will any standards take into account existing sectoral standards, either through NSB or industry bodies?
- What is the purpose of the information exchange?
- What information needs to be exchanged and at what level to achieve the goals of CDBB?
- What level of interoperability or integration is needed or to be attempted?
- What is the frequency of update?
- What is the role of CDBB in market creation and enablement?
- Is the purpose of the standard to converge thinking through use or to crystalize developed thinking and practice?
- Will it issue standards for mandate, standards for adoption, codes of practice, or guidance documents?

This should allow the establishment of the following levers:

- Develop a systematic standardisation foresight work stream alongside the research framework and the stakeholder engagement feedback.
- Public procurement should be leveraged to support dissemination of new practices but Demand side stakeholders, the client, need support to be able to specify their needs in a way that enables competition and the application of innovative new ways of delivering products and services.
- Standards that specify performance and functionality over those that are tech-specific and solution descriptive.
- DBB should consider PASs as a tool for the future, but the development of PASs should be under a wider strategy for standardisation to ensure proper development, adoption, monitoring and review to enable the CDBB mission to unite.

5 Conclusions and recommendations

At its core, Agile methods have the ability to develop new levels of confidence in solutions as the information and technology becomes available. They encourage constant feedback from the users and provide tools to iterate on solid ground.

While the benefits of standards are clear to encourage market adoption and scalability of solutions, standardisation bodies rely on establish consensus and proven best practice to deliver standards. This is in many ways counter to the concept of agile. These bodies fulfil a function of providing proven, trusted methods to codify knowledge developed over years.

Industry bodies, however, have the liberty to be more agile, to take greater risk in working towards innovative solutions. They can coordinate market players to invest in developing novel solutions to challenges that arise at a pace never seen before. It is encouraging to see the pace at which new technologies are changing and shaping the way we do things today and industry bodies have the opportunity to enable faster consensus in collaboration with their members. They play an important role in helping to identify new opportunities and support their development sufficiently to smooth their transition into recognised de facto standards.

The CDBB has an opportunity to join the dots for a number of these organisations in pursuit of its mission, creating strong links to the NSBs relevant to the built environment and digital technologies. It also has the potential to lead the way through the core research and horizon scanning being developed in one of the most influential research organisations in the world.

By composing a clear mission and a roadmap to develop increasing levels of capability and knowledge for a Digital Built Britain, the Centre can coordinate action advocated by UK government to ensure standards support the rapid growth of an information rich built environment, ultimately supporting the development of a number of service industries in the UK and beyond.

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