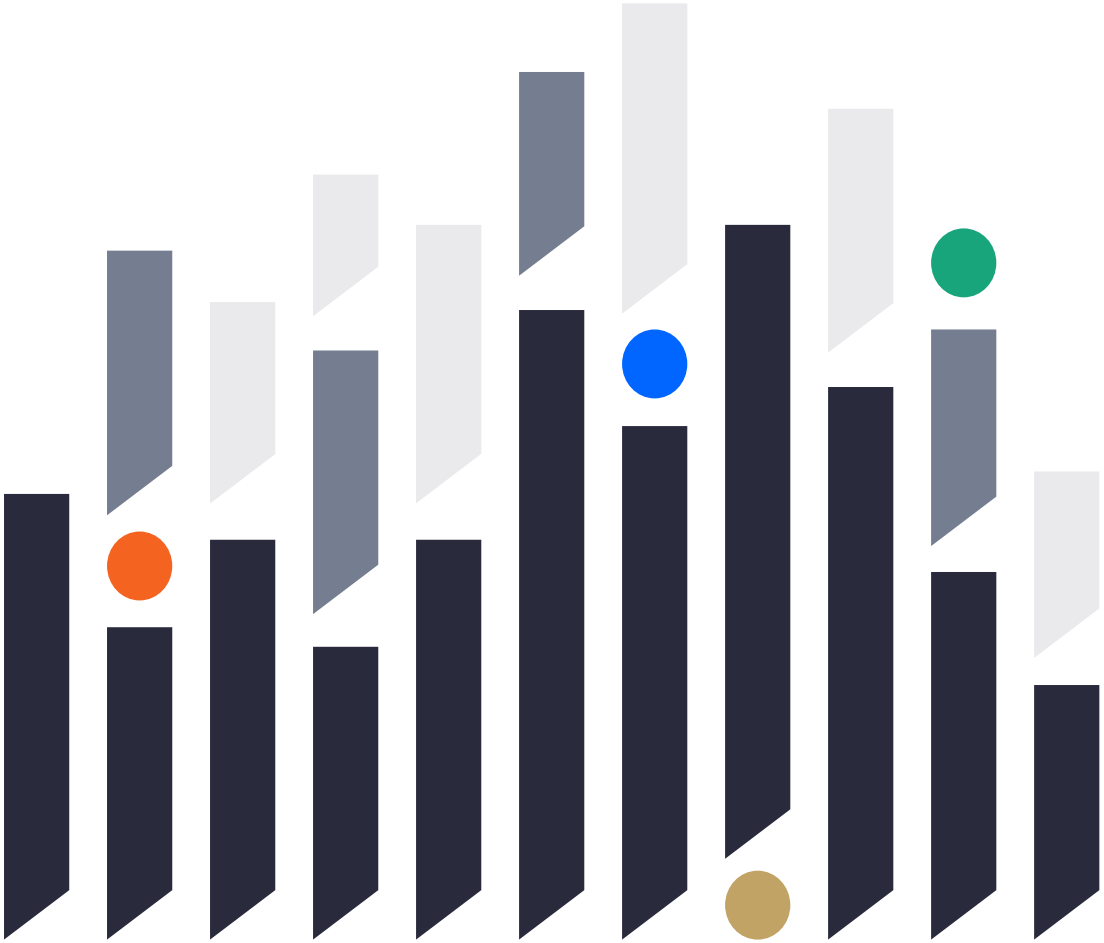
UNIVERSITY OF CAMBRIDGE
Centre for Digital Built Britain

CDBB L2C PROGRAMME

Standards landscape and information management systems



urban innovation labs

WP2 – Meta standard and Standard Landscape

Executive summary

The is workpackage consists of two elements, a review of the standards landscape and the development of new meta-standards.

The conventional approach to standards mapping has been developed by UIL to include a so called broad:deep approach. 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.

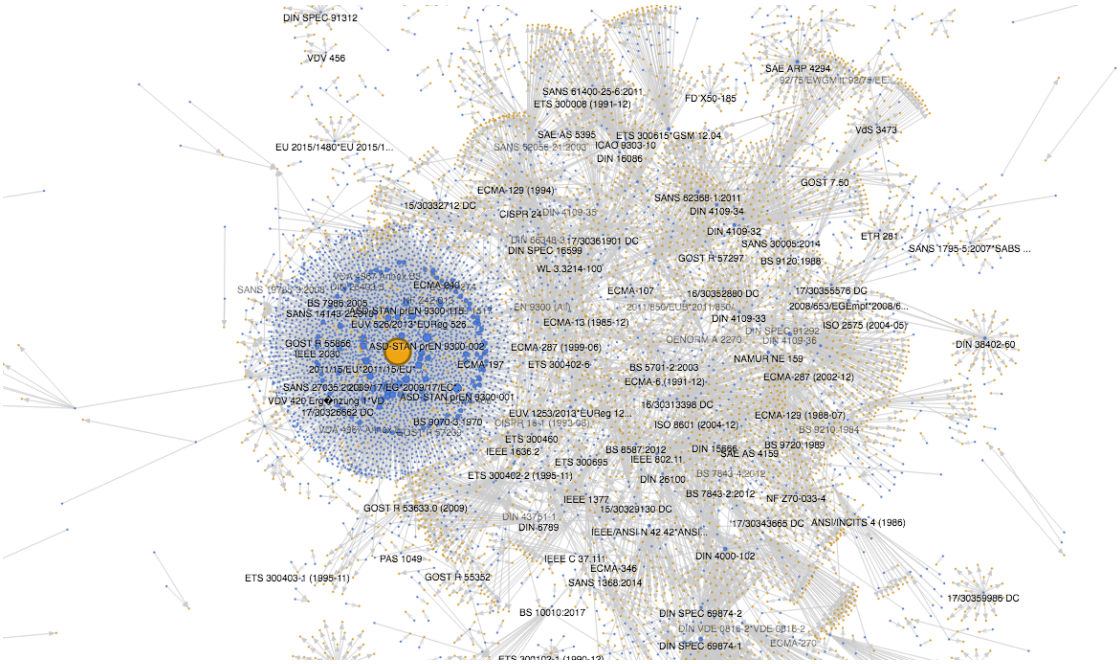


Figure 1 - Relationship diagram of sub-set of de jure standards within the scope of CDBB

The analysis has indicated 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. However, subsequent analysis has indicated that de facto standards are more prevalent in this stage of the lifecycle, but these are not considered by the conventional approaches to developing standard landscapes. This echo's the findings in WP1 that showed that the National Standard Bodies are stakeholders of national standards, but standardisation exists in industry and special interest groups who also define standards, guidelines and codes of practice, all of which help govern how different business, systems or products function, interoperate and integrate.

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 features and functionality that would impossible with an existing standard set. It has been shown to help with the discoverability of the correct standard by focusing the users attention to the appropriate area and providing a logical order, particularly through a life cycle, of often abstract definitions.
The process of creating a meta standard is quite time consuming, subjective and reliant on a 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.

The concept has been successfully proven with further use cases of ISO55001, ISO55002, BS1192:7 and PAS185, which has highlighted a series of areas for consideration in future standard updates. It would now benefit from user testing to assess the mapping and analysis.

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

The asset-data landscape gives a broad context for standards for CDBB. It provides a shortlist of standards, but not the 'recommended' standard(s) in a particular context. In heavily regulated industries, BSI have invested in developing tools that align process workflows and standards. A good example of this is compliance navigator[1] that supports organisations in the medical device sector. Such tools do not exist in the DBB space and so the landscape needs research into how standards could be mapped to activities, providing useful user specific tool that can support a more effective and compliant delivery of services for the built environment.

[1] https://compliancenavigator.bsigroup.com/

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Part 1 - Standards landscape for Digital Built Britain

Digital Built Britain (DBB) has a broad scope, covering over 11,000 standards across the construction and information technology space. Like many new and emerging cross-domain topic areas (Internet of Things, Big Data, Smart Cities) standardisation activities in the context of DBB are based on application of existing 'vertical' standards from established domains and the development of new 'horizontal' standards. These horizontal standards can provide integration between established vertical standards or 'fill the gaps' where no standardisation exists.

A standards landscape provides a view on a domain of interest from a standards perspective. The domain of interest can be 'any' subject area, but the relevance of the standards landscape is very dependent on the ontology used to define the particular domain of interest. The ontology needs to be informed by the purpose of the standards landscape; this is analogous to a road atlas: if a standards landscape is not scaled appropriately it will deliver too much or too little information.

This work undertook a series of database investigations to establish the standards pertinent to different viewpoints of the DBB subject area. To undertake more detailed research on standards application, members of the UIL consortium used the results (spreadsheets of standards) from the BSI investigations.

As the UK National Standards Body, BSI were unable to provide specific advice or interpretation on the contents of the landscape. BSI's role is to present the facts of the landscape and provide observations for technical experts to investigate in more detail.

1 Standards Landscape for L2C Digital Built Britain - Introduction

1.1 Landscape Mapping

Standards Landscape mapping relates to the identification and categorisation of standards within a particular topic of interest. Formal standards metadata provides information on the standard citation, plus information on the committee that developed the standard and, importantly, normative references used within the standard. This effectively defines a 'parent:child' relationship between the standards. Within a group of standards it is therefore possible to produce a network of standards dependencies, remembering that a standard may be a normative reference within many 'child' standards.

This landscape can then be used to augment default relationships between standards, with sector specific topics and areas of interest. At its basic level, a landscape map would provide a list of 'in scope' standards. This is typically used when proposing new areas of standardisation to identify potential conflicts between new and existing standards. Further analysis can yield insights such as standards gaps, where topics have no standards associated with them. Landscapes analysis can also be conducted in the context of particular stakeholder groups, business workflow or policy frameworks to establish insights such as 'Which standards support this piece of legislation?'

1.2 Approach for the L2C project

The approach used followed the established approach for standards landscape mapping and was undertaken by the BSI Knowledge Centre with expert technical and standards input from the UIL team.

The landscape mapping activity established a topic ontology for Level 2 Convergence (L2C) to provide terms that can be used to search the standards databases. Formal Standards do have a high-level subject classification, but this is too imprecise to undertake a landscape mapping. For this a customised ontology of terms needs to be established. One of the subject ontologies is shown in Figure 2 below:

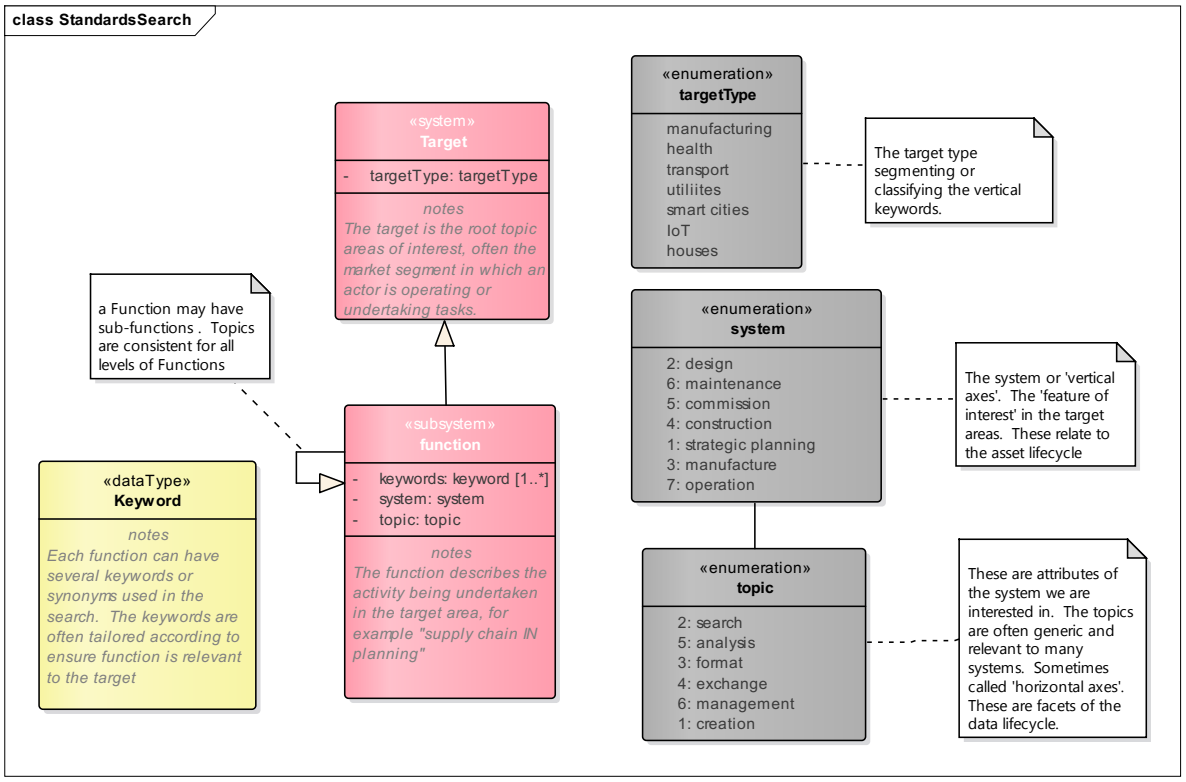


Figure 2 - Ontology for the broad L2C landscape

The ontology is based on a trio of concepts; this allows for search of standards that are relevant to a particular topic in a given application area (system) in a given domain (target). For example, we may be able to find standards on manufacturing::design::analysis, but not transport::design::analysis. Wildcards and Boolean operators allow us to refine our search. The outcome of the search may also inform how the ontology needs to evolve.

Each system and topic in the ontology is represented by a number of synonyms. These are used to provide key words to query the standards database using an iterative process to refine the keywords to return appropriate standards in terms of both relevance and quantity.

Matrices and networks can be constructed of the ontology based on the results of the standards search. This can include statistical representation of the results, for example, a pie chart or stacked bar graph of the number of standards in each topic for a given system.

For the L2C project, an extensive number of landscapes were generated for different topic areas and also at different 'scales' in the DBB landscape. These are covered in the following section but comprise briefly of a broad scope standards landscape covering the standards related to DBB,

mapped across the asset lifecycle and data lifecycle, highlighting the gaps across the landscape. The standards landscape was filtered for the following target areas:

- Transport
- Utilities
- IOT
- Smart Cities
- Manufacturing
- Health
- Housing

The aim of this landscape is to provide a context for generic data management activities in the context of DBB activities and provide a heat map of standards activity.

Fine scale standard landscapes for the scope of DBB as outlined above covered the following target areas:

- Transport
- Utilities
- Housing
- Health

These standards landscapes covered sub-topics of these thematic areas, intercepted with specific service areas related to the topics, for example, 'capacity planning for a rail station'. The aim is to be able to identify standards that an actor performing that service should follow as best practice. For this work four separate spreadsheets were supplied.

This 'broad scale v fine scale' approach to landscape mapping is a new approach developed by UIL and has been tested on this project to discover if it provides insights into how standards can be discovered and used. For large multidisciplinary subject areas like IoT and Smart Cities, BSI have found that single 'all encompassing' landscapes can be too large providing little support to experts to interpret. It is hoped that this approach can provide both breadth and depth to support the use and selection of standards in a particular context.

2 Research methodology

At BSI is it largely, but not exclusively, based on the content held within formal standards catalogues. BSI has a dedicated Knowledge Centre of information professionals who manage BSI's catalogues and databases.

2.1 Resources

The leading standards database Perinorm was used for this piece of research. Perinorm is a bibliographic standards and technical regulations reference database, with indexed international standards from over 200 organizations in 23 countries, totalling more than 1,700,000 records. The data is sourced directly from standards bodies and updated on a monthly basis, ensuring high quality, relevant data.

2.2 Keywords

Searches of Perinorm are dependent on the selection of appropriate keywords based on the subject area ontology. The selection of keywords used for the searches is an iterative process based on the quality of the results returned for each keyword combination. Keywords are added, removed and refined, to return the most appropriate (in terms of relevance and quantity) list of standards.

2.3 How the research was carried out

The formal standards piece of research was split into three main phases:

2.3.1 Phase 1 (Detailed Landscape)

- The L2C project team discussed the different available options and established the most appropriate approach to carry out the standards research.
    - A number of key target areas were identified. For each target area a system:topic matrix was created. The system facets were defined on the vertical axis of the matrix, and two topics on the horizontal axis.
- The matrix served as a basis to identify relevant keywords and phrases relevant to each target area. The system facets described a particular aspect of the target area. The topic keywords describe a service or activity being performed. The list of keywords and phrases was the result of a joint effort from the subject matter experts.
    - To ensure that the selected keywords and phrases were suitable to the terminology used in the standards world, the project team and the Knowledge Centre verified the keywords by running individual searches on the standards database and establishing whether these would retrieve any standards.
    - Where standards were not found, the Knowledge Centre team tried to adapt the original terms provided to the 'standards language' by looking for synonyms or related terms found on the International Classification for Standards (ICS) codes as well in the descriptors field from some core relevant standards.
    - In some cases, the synonyms or related terms still didn't find any results; this clearly defined the gaps in standardisation.
- Once all keywords were agreed by the project team, the Knowledge Centre carried out Perinorm searches on each individual keyword or group of related terms to obtain the total number of standards found per search. This gave an idea of the overall count for the entire standards landscape, which helped in phase 2 to establish the number of standards that should be expected when combining the sector specific system (vertical axis) and the keywords within each topic (horizontal axis).

2.3.2 Phase 2 (Detailed Landscape)

- The second phase of the research began in order to narrow the overall results for each vertical by combining these with the keywords for each service 1 and 2.
- The subject matter experts in the project team assisted the Knowledge Centre team in refining the searches that brought a considerably large number of standards, in other words, those higher 2,000 results.
- Several test searches were conducted allowing them to identify the keywords that were causing the retrieval of a large and irrelevant number of results. A decision was made to

remove these terms from the searches, so that the total number of standards results was reduced and more focused.

2.3.3 Phase 3 (Broad scale Landscape)

- Phase 3 mirrored the first and second phase comprising of the asset lifecycle as the system, and facets of the data lifecycle as the topic areas.
- The results from this landscape were subsequently filtered to the target areas used in the detailed landscape.

2.4 How the landscape data is presented

The results are presented in a separate Excel Workbook, along with the relevant background information demonstrating the search resources. The workbook includes:

1. Matrices for all four detailed thematic targets areas plus the broadscale asset-data target.
2. Boolean Keyword Searches: this explains how keywords were combined to yield the cross representation results of the vertical sectors by the horizontal services for each matrix.
3. Standards Results: the complete list of the search results. The data herein is designed to be manipulated in order to view the results by both the vertical sector, the horizontal service, and by each sub-areas within the main sector.
4. An overview of how to make use of this workbook is provided below:

For each standard in the landscape following information is provided:

- Document identifier
- Publication date
- Title
- Abstract
- International relationship
- Cross references
- Committee reference
- Descriptors
- Classification
- Issuing body

2.5 How to use the workbook

- The data has been designed to be manipulated by using the filters in columns A, B and C. Column A contains the vertical sector data such as Construction and Utilities, column B contains the broad horizontal (topic) technology layer, and column C allows for further precision by narrowing the results by the sub sector areas. For example, if you want to know

which standards are applicable to ‘transport hubs’ in relation ‘Service 1', you would filter by ‘Transport’ in column A and ‘Service 1’ in Column C.

- Ultimately, this type of data manipulation allows for a quick and simple query of the data to ascertain the relevant standards based on any combination of the vertical sectors and services, as well as areas within the asset lifecycle and any of the data facets.

2.6 Limitations of use

The use of Perinorm for this project also presented some challenges:

1. Initial keywords were either too broad or were not relevant to the accepted Standards Indexing terms. This required several iterations testing keywords, excluding broad ones and finding synonyms for the ones that were too specific.
2. Using generic terms leads to irrelevant standards found within the search results. Furthermore, many standards are indexed in Perinorm with generic terms which may be used in a different context that falls out of the scope of the research. This makes it very difficult to refine the search results in an automated way, and sometimes may require the removal of standards from the results manually. This, however, breaks the research methodology and makes updating the data in the future difficult.
3. There are inconsistencies in the indexing of standards included in Perinorm. Some EN, ISO and IEC standards are indexed differently to the National adopted version of same EN, ISO or IEC standards. This means that some standards would not be found depending on which keywords are used in the searches. A review of the descriptors is required to understand why some expected standards are not being retrieved.
4. Duplication of standards were found in three different ways:
    - Some European and International National Standards bodies from overseas such as France and China adopt EN and ISO standards using their own numbering system. This means that the original EN or ISO standard numbers do not appear in the document identifier of the adoptions; this makes it very difficult to remove adopted versions of EN or ISO standards from our searches. To date, the only way to remove these duplicates has been a manual task.
    - There are, in some cases, various versions retrieved in Perinorm within one search, where the variance of versioning and naming protocols across the worldwide IoT Standards Bodies means that our strategic searches do not pick up on the duplication.
    - The third type of duplication is when a standard comes up in the results in more than one horizontal or vertical. Although it may not give a true number of total standards, this type of duplication allows the demonstration of overlap between different sectors or technologies.

2.7 Perinorm licence

The Perinorm database of standards is supported by three bodies, of which BSI is one. However, this does not give BSI the right to republish the content without agreement from the other parties. For this reason, a Perinorm licence was obtained by UIL to enable BSI to pass the results of the searches onto them for subsequent analysis.

3 Broad scale standards landscape for L2C

3.1 Overview

The broad scale standards landscape is informed by two viewpoints of DBB as shown in Figure 1: the asset lifecycle view and the data lifecycle view. Fundamental to DBB is the management of information about the asset through the asset lifecycle. The asset lifecycle includes the design, construction and operation of the asset. The data lifecycle includes the creation, storage and exchange of data and information. Full explanation of these are given in the table below:

Data Lifecycle (topic)		Asset Lifecycle (system)	
Topic	**Scope**	**System**	**Scope**
Creation	How data is created, primarily through measurement.	Strategic Planning*[*]	Determination of options for future scheme. Creation of brief.
Search	How data is discovered and published for discovery.	Design	Creation of information for manufacture, construction and use.
Format	The structure, content and encoding of the data.	Manufacture	Creation of components or systems within factory environment.
Exchange	Exchange and messaging protocols of data to facilitate interoperability.	Construction	Building an asset.
Analysis	Standardised approaches and methods for data analysis.	Commission	Starting service for the first time and validation of function before use.
Management	Process, procedures and techniques for data management.	Maintenance*	Ongoing activities to ensure assets remain fit for purpose.
		Operation	Activity to asset to allow a service to be provided.

Table 1 - System and Topic keywords for the asset-data landscape

The standards search examined standards at the interception between these system:topic viewpoints, for example, standards related to the creation of data at each stage of the asset lifecycle. This would provide the basis for analysis such as:

- Are there any standards specifically related to data capture in the context of the asset lifecycle?
- Are there are different data capture standards for each phase of the asset lifecycle?

The same can then be applied across all facets of the data lifecycles, for example, standards related to data exchange during the operation phase of an asset. This approach gives a broad contextual

[*] it is worth noting that topics such as archive/delete information is assumed part of each topic and decommission of the asset is an outcome derived from the activities across planning and maintenance.

standards landscape. It would indicate the existence of standards that could be used in that context, providing pointers for standards use.

3.2 Observations

The search identified just over 11,000 unique standards in this landscape. This is a high number but expected given the subject area (construction and IT have a large standards portfolios). A heat map of the standards distribution is shown in Figure 5. This standards landscape was also filtered to identify the relevance of this generic landscape to particular target areas. The target areas are:

- Transport
- Utilities
- Smart Cities
- Internet of Things
- Heath
- Housing

The aim of this was to identify variations in 'heat maps' across and between target areas. Figure 2 shows the distribution of the filtering across the target areas. This shows that utilities and manufacturing account for over 50% of the standards between them. There is nothing surprising in this, as these are extensive and established target areas. Likewise, the proportion of standards returned for IoT and Smart Cities are quite small, but these are emerging topic areas with small standards portfolios, so again this is not unusual.

A more interesting observation is when the uniqueness of the standards is considered. Figure 3 shows the uniqueness of the standards in the asset-data landscape to each of the filter terms in Table 1. This shows that almost half the standards (43%) had no matches to any of the targets. This means they are either generic or matched to other areas. Given the topic areas chosen in the filters, this latter case would not be expected and most asset-data standards are agnostic to the target area.

Similarly, where the filters do match, most standards are unique to one target area and only a total of 19% of standards explicitly matched to more than one topic. No standard matches to more than three target areas. Further analysis would be interesting to determine if the standards in a particular target area of the data-asset landscape reference the generic data-asset standards. For example, 'do standards for transport data exchange reference generic data exchange standards?' If data exchange standards in each target area have different normative references, then this may indicate a fundamental barrier to interoperability for CDBB.

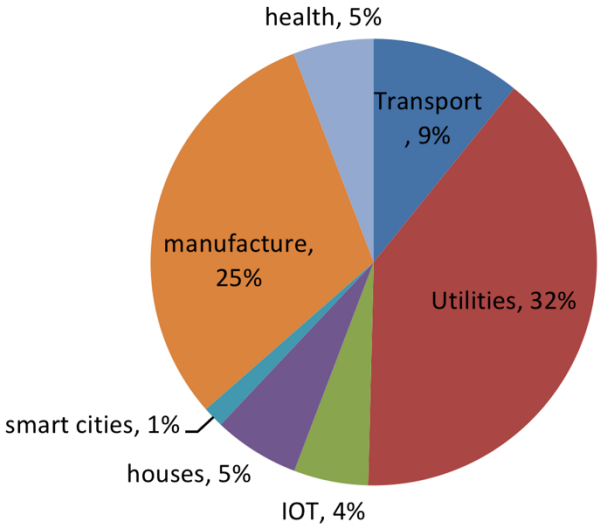


Figure 3 - Distribution of filtered standards by target area

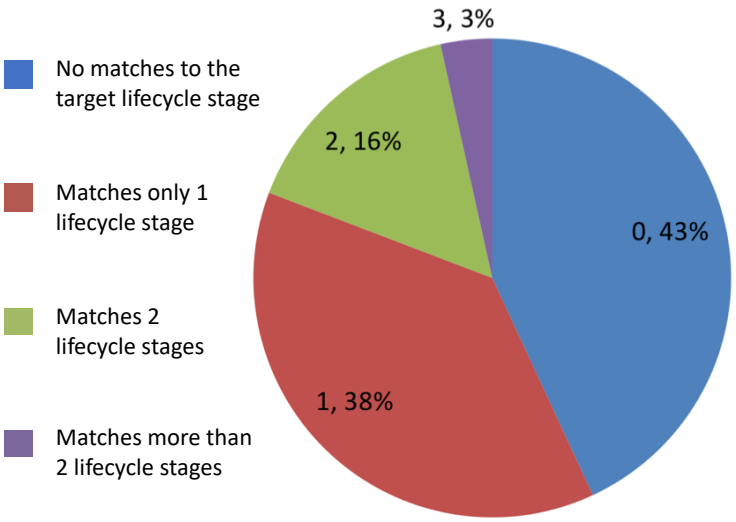


Figure 4 - Standards Filter Matches showing uniqueness

3.3 Landscape Heat Maps

Heat maps were generated for all of the asset-data landscapes, shown in Figure 5. The first heat map is for the entire asset-data landscape; the remaining seven are for the individual target areas.

	Strategic Planning	Design	Manufacture	Construction	Commission	Maintenance	Operation	TOTAL	
All									
Creation	109	232	120	164	129	159	23	936	8.5%
Search	30	145	30	64	66	48	14	397	3.6%
Format	97	646	189	184	471	179	14	1780	16.1%
Exchange	281	1802	591	664	1165	726	89	5318	48.1%
Analysis	22	39	30	30	19	80	3	223	2.0%
Management	257	868	154	376	364	338	53	2410	21.8%
TOTAL	796	3732	1114	1482	2214	1530	196	11064	
	7.2%	33.7%	10.1%	13.4%	20.0%	13.8%	1.8%	100.0%	
Transport									
Creation	17	33	17	27	27	20	3	144	14.9%
Search	5	21	10	8	8	5	0	57	5.9%
Format	14	55	26	20	31	9	2	157	16.2%
Exchange	27	107	60	60	122	29	20	425	43.9%
Analysis	2	5	1	3	1	6	0	18	1.9%
Management	21	38	15	38	35	17	3	167	17.3%
TOTAL	86	259	129	156	224	86	28	968	
	8.9%	26.8%	13.3%	16.1%	23.1%	8.9%	2.9%	100.0%	
Utilites									
Creation	47	73	61	74	65	52	18	390	11.0%
Search	5	26	9	17	22	12	7	98	2.8%
Format	23	113	64	39	76	47	5	367	10.4%
Exchange	147	521	428	270	359	208	53	1986	56.1%
Analysis	6	10	17	6	9	29	3	80	2.3%
Management	62	168	93	108	84	90	16	621	17.5%
TOTAL	290	911	672	514	615	438	102	3542	
	8.2%	25.7%	19.0%	14.5%	17.4%	12.4%	2.9%	100.0%	
IOT									
Creation	1	6	1	3	4	4	0	19	3.9%
Search	0	3	1	0	4	0	1	9	1.9%
Format	2	6	8	3	11	0	0	30	6.2%
Exchange	33	87	39	26	68	45	6	304	62.9%
Analysis	0	3	0	1	0	4	0	8	1.7%
Management	13	40	8	7	24	21	0	113	23.4%
TOTAL	49	145	57	40	111	74	7	483	
	10.1%	30.0%	11.8%	8.3%	23.0%	15.3%	1.4%	100.0%	
Houses									
Creation	24	30	5	25	4	9	2	99	17.7%
Search	7	12	7	9	1	6	8	50	9.0%
Format	9	23	4	20	10	8	3	77	13.8%
Exchange	39	66	22	55	31	13	9	235	42.1%
Analysis	0	2	0	3	0	2	0	7	1.3%
Management	12	27	7	19	11	8	6	90	16.1%
TOTAL	91	160	45	131	57	46	28	558	
	16.3%	28.7%	8.1%	23.5%	10.2%	8.2%	5.0%	100.0%	
Smart Cities									
Creation	7	4	0	3	2	0	2	18	13.2%
Search	0	0	1	0	0	0	1	2	1.5%
Format	1	2	7	0	5	0	0	15	11.0%
Exchange	15	17	15	8	13	8	3	79	58.1%
Analysis	0	2	0	0	0	3	0	5	3.7%
Management	2	9	0	1	1	3	1	17	12.5%
TOTAL	25	34	23	12	21	14	7	136	
	18.4%	25.0%	16.9%	8.8%	15.4%	10.3%	5.1%	100.0%	
Manufacture									
Creation	14	59	16	24	18	34	0	165	6.0%
Search	16	66	21	20	11	24	11	169	6.2%
Format	53	212	83	76	150	71	8	653	23.8%
Exchange	74	272	101	113	189	86	17	852	31.1%
Analysis	7	26	6	10	2	20	1	72	2.6%
Management	96	309	66	93	101	157	6	828	30.2%
TOTAL	260	944	293	336	471	392	43	2739	
	9.5%	34.5%	10.7%	12.3%	17.2%	14.3%	1.6%	100.0%	
Health									
Creation	2	9	4	7	8	11	0	41	7.8%
Search	0	5	0	5	4	4	1	19	3.6%
Format	18	31	7	14	25	8	0	103	19.7%
Exchange	24	47	25	28	73	28	4	229	43.8%
Analysis	5	3	6	2	5	6	2	29	5.5%
Management	12	26	9	16	23	15	1	102	19.5%
TOTAL	61	121	51	72	138	72	8	523	
	11.7%	23.1%	9.8%	13.8%	26.4%	13.8%	1.5%	100.0%	

Figure 5 - Heat Maps of Standards in the Asset-Data Landscape

The heat maps are red for hot areas (most standards), blue for cold areas (fewest standards) and white in the middle. Based on the patterns observed from the heat maps, a number of preliminary conclusions can be drawn in respect of standards in the context of CDBB2 as follows:

- The operational phase of the asset lifecycle is consistently the coolest part of the landscape across all topics.
    - Smart Cities and Housing are the only topics where the operational phase is significantly warmer than average.
    - This would suggest that, at a general level, operational best practice is not widely standardised. This should be investigated further if the evolution of BIM relies on data interoperability at the asset operation phase.
- Data and information exchange is the warmest part of the landscape across all topics.
    - This is not unexpected as data exchange standards are a very common and obvious areas for standardisation, in other words, they are fundamental to collaboration.
- The coolest topics for data and information relate to searching for data and data analysis
    - 'Search' covers how data is published and discovered and so limited standards in this area would reflect the anecdotal reports that 'the right data is hard to find'.
    - Analysis covers the existence of proven and document approaches to how data is processed to derive information.
- Related to the above, the coldest part of the landscape relates to data analysis in the operational phase of the asset lifecycle with only three (0.03%) of the total standards. This would clearly indicate this is an area for research and possible future standardisation actions, given the broader aim for analytics to support the operation of buildings.
- The hottest part of the landscape relates to data exchange during the design phase of the asset lifecycle, indicating the number of different information exchange definitions that exist at a process and device level.
- Note that while IoT has gained extremely high interest in industry, it is a relatively new area of focus and therefore the low numbers in standards for this "market" is not surprising. There are many initiative and working groups currently addressing this new market opportunity which has its roots in the M2M communication, for which numerous de jure, as well as de facto, standards exist.

More detailed investigation at the standard level would be interesting to see how the 'heat' is realised, for example, there are 87 standards related to data exchange in asset design system in the context of IoT. It could be useful to understand the scope of these standards and how they relate to one another.

4 Detailed scale standards landscape for L2C

As outlined above, the asset-data landscape gives a broad context for standards for CDBB. It provides a shortlist of standards, but not the 'recommended' standard(s) in a particular context. In heavily regulated industries, BSI have invested in developing tools that align process workflows and standards. A good example of this is compliance navigator[3] that supports organisations in the

[2] These are based on results of the landscape searches and would need to be verified by inspection of each of the standards themselves. This is beyond the scope of this project.

[3] https://compliancenavigator.bsigroup.com/

medical device sector. Such tools do not exist in the DBB space and so the landscape needs research into how standards could be mapped to activities.

The approach used for the detailed level landscapes was to consider an actor in a target area, and describe the service that the actor performs as a user story. For example, "I am a facilities manager in the utilities sector and I need to specify the location of sensor to optimise building heating and cooling". This is a different context to "I am a facilities manager in the utilities sector and I need to integrate information from different legacy sensor system". In both cases the actor is the same, but role they are performing is different. Therefore, so are the standards they will need to support.

The topic areas considered for actors were as follows:

- Transport
- Utilities
- Health
- Housing

4.1 Transport

9427 standards were returned using the keywords specified in Annex 7. A heatmap of the results is shown in Figure 5 below. The two service areas used to define the system keywords were:

- Service 1: "managing real-time (road) traffic flow intelligence"
- Service 2: "dynamic management of traffic signals (lights, VMS, etc.) based on real-time information"

	Transport Station	Buildings open to the public	Railway Station	Intelligent Transport Systems	Smart Cities	Road	Traffic		
service 1	39	900	20	22	0	198	210	1389	14.7%
service 2	8	395	6	78	3	6785	763	8038	85.3%
	47	1295	26	100	3	6983	973	9427	
	0.5%	13.7%	0.3%	1.1%	0.0%	74.1%	10.3%		

Figure 6 - Heat map of results – transport

4.2 Utilities

176O standards were returned using the keywords specified in Annex 7. A heatmap of the results is shown in Figure 6 below. The two service areas used to define the system keywords were:

- Service 1: "Management of demand side data"
- Service 2: "Management of peak load"

	smart cities	smart grids	electricity	microgrid	smart buildings		
service 1	28	67	1354	6	22	1477	83.9%
service 2	1	6	275	0	1	283	16.1%
	29	73	1629	6	23	1760	
	1.6%	4.1%	92.6%	0.3%	1.3%		

Figure 7 - Heat map of results – utilities

4.3 Health

822 standards were returned using the keywords specified in Annex 7. A heatmap of the results is shown in Figure 7 below. It should be noted that for the Healthcare detailed searches Service 1 and Service 2 are different ontologies for the same service to determine which provided the best results. The two service areas used to define the system keywords were:

- Service 1: care of elderly
- Service 2: bed allocation

	Health Care	Hospital Beds		
service 1	671	29	700	85.0%
service 1	124	0	124	15.0%
	795	29	824	
	96.5%	3.5%		

Figure 8 - Heat map of results - Health

4.4 Housing

10,973 standards were returned using the keywords. These results were supplied to UIL analysts for interpretation. A heat map of the results is shown in Figure 8 below

	Architect	Design	Domestic	Enigneer	Residential	Structure		
service 1	172	1336	501	779	384	1472	4644	42.3%
service 2	337	1716	655	1240	509	1872	6329	57.7%
	509	3052	1156	2019	893	3344	10973	
	4.6%	27.8%	10.5%	18.4%	8.1%	30.5%		

Figure 9: Heat map of results - Housing

5 Broadscale:Finescale Interaction

An area of investigation was the utility of broad scale and finescale searching of standards to create landscapes. In the past, this has always been problematic due to the number and quality of standards returned. From a standards development perspective this is addressed through repeated iterations until a subset of standards is arrived at that could be considered normative references for the new standard. In the detailed level searches, a similar approach was undertaken. For this project only two iterations were performed, but repeated iterations could be undertaken until a final set of standards is arrived at that supported a particular use case or activity in the best possible way.

For the broadscale landscape there is no absolute target for the standards, but a method to define the scope of standards through keywords. Using the data:asset ontology 11,000 standards were returned, filtered to particular target areas.

What is interesting is that, in terms of the standards common to both, the correlation between the board scale and finescale view of the same target area is generally very small. In other words, a standard in the data-asset landscape that meets the transport filter may not appear in the detailed transport search and vice versa.

A systematic match was undertaken of standards appearing in the asset-data landscape and those appearing in the four finescale landscapes. The match criteria between the two was an exact match on the Document Identifier. The results are shown in Table 2:

Finescale Target	standards from finescale target in asset-data	standards from asset-data in the finescale target
Transport (9426 standards)	153 (2%)	263 (1% total, 27% filtered)
Utilities (1760 standards)	55 (0%)	102 (2% total, 27% filtered)
Health (794 standards)	19 (2%)	40 (0% total, 8% filtered)
Housing (10971 standards)	102 (0%)	124 (1% total, 3% filtered)

Table 2 - Broad scale:Finescale standards intersection

Column 1 gives the number of standards from the finescale landscape that appear in the asset-data landscape. Column 2 gives the reciprocal, in other words, the number of standards from the asset-data landscape that appear in the finescale landscape. For this, two statistics are given: one for the full total asset-landscape and one just for the asset-data filtered for the different targets.

First of all, it is important to point out that the intersection between the standards is not the same in both directions due to duplicates in the search results. These duplicates are 'by design' as the finescale ontologies required standards to be uniquely identified for each system:topic interaction.

A manual assessment was made of this low correlation to determine the reasons. One reason for this is that the match criterion was an exact match on the document identifier and there were several examples of where different parts of the same standard was identified to be in different landscapes. For example, DIN30795-1 was in the detailed Transport landscape and DIN30795-7 was in asset-data (and filtered correctly as a Transport standard).

Another reason why standards in the finescale landscape did not appear broader landscape is because fundamentally they were not defined in terms of data AND asset keywords (only one or the other). The AND could be relaxed, but then the problem is a much larger landscape and also only in one dimension (data OR asset). In effect, the filters are being applied at a target level and then combined. It is worth noting that if two broader searches were performed the results are likely to have greater overlaps and intercepts.

The third point, and related to the above, highlights that landscapes are very dependent on the ontology used to define them. It can be seen there is a far greater match for Transport and Utilities than Housing than for the filtered asset-data landscape.

Finally, it should be remembered that both the broadscale and fine scale landscapes established in the project are all correct for their intended purposes. However, because they have different ontologies they cannot be considered interoperable in all cases. The approach used to define the system and topic ontologies is fundamental to the standards returned. The broadscale and finescale ontologies represent different journeys and what you see (intercepting standards) on that journey will be different.

6 Annex 1

6.1 Standards Source and Development Organisations

For the purpose of this research, formal standards searches have been carried out for the following list of countries and Standards Development Organisations worldwide:

- **Leading European standardization organisations:**
  - Germany (DIN)
  - Austria (ON)
  - Belgium (NBN)
  - Denmark (DS)
  - Spain (AENOR)
  - France (AFNOR)
  - Italy (UNI)
  - Norway (STANDARD ONLINE AS)
  - Netherlands (NEN)
  - Poland (PKN)
  - Czech Republic (CSN)
  - UK (BSI)
  - Russia (GOST)
  - Slovakia (UNMS)
  - Sweden (SIS)
  - Switzerland (SNV)
  - Turkey (TS)
  - Lithuania (LSB)

- **European and international standardisation organizations:**
  - CEN European Committee for Standardization
  - CENELEC European Committee for Electrotechnical Standardization
  - ETSI European Telecommunications Standards Institute
  - IEC International Electrotechnical Commission
  - ISO International Organization for Standardization

- **US-based standardisation organizations:**
  - ANSI American National
  - Standards Institute
  - API American Petroleum Institute
  - ASME American Society of Mechanical Engineers

- ASTM American Society for Testing and Materials
- EIA Electronic Industries Alliance
- IEEE Institute of Electrical and Electronics Engineers
- NEMA National Electrical Manufacturers Association,
- NFPA National Fire Protection Association
- SAE Society of Automotive Engineers
- UL Underwriters Laboratories

- **Others:**
  - ITU International Telecommunication Union
  - JSA Japan Standards Association
  - CSA Canadian Standards Association
  - SABS South African Bureau of Standards

6.2 Search Terms

6.2.1 Asset-Data

Concept	Term/Facet	Synonym
Data	Creation	Capture
Information		Measure*
		Monitor*
		Observation
	Search OR	Catalogue
	Publish	Metadata
		Discovery
		Archive
	Format OR	Structure
	Product	Content Model
		Encoding
		Schema
	Exchange	Communication
		Interoperability
		Transmission
	Analysis	Visualisation
		Portrayal
		Error Handling
	Management	Lifecycle
		Audit
		Security
		Reuse
		Destruction
		Quality

Concept	Term/Facet		Strategic Planning		Brief and Design		Manufactur*		Construction		Commission and Handover		Maintenance		Operation		Services (externally focussed)		Outcomes	
Data or Information			Risk OR Contract OR "Management accounting" or account OR Purchas* OR Cost or costing OR Tender* OR "Life cycle*" OR Procurement or procure OR "Construction works" OR Value OR Business OR Strateg* OR Policy or policies OR Environmental or environment OR Efficiency or efficient OR planning OR benefit* OR investment or invest or finance or investing		Building* or quality or Specification* or Design* or "Information security" or "Architectural design" or Sustainability or "Supply chain" or Infrastructure or structural or "setting-up conditions" or "check lists" or briefing or "capability approval" or structure		"Construction products" or offsite or "type testing" or modular or markings or conformity or durability or "fire resistance" or "thermal performance" or "construction materials" or tolerances or mechanical or "Electronic equipment and components" or emission or Manufactur* or		"Project management" or "Engineering works" or Construct* or safety or site or "site investigation*" or "personal protective equipment" or installation or workmanship or geotechnic*		"Technical document*" or commission* or "construction operations" or "visual testing" or "safety measures" or operations or "data exchange" or validat* or "hand over" or handover		"Facility management" or maintenance or testing or report* or assurance or inspect* or examin* or checklist* or "check list*" or assessment or assessing or "occupational safety" or "equipment safety"		"Asset management" or "Building service*" or operational or "field testing" or "electrically operated devices" or "thermal environment systems" or "air-distribution systems" or "energy management" or ventilation or "service contract*" or "organizational resilience" or "organisational resilience" or "business continuity" or "transport* services" or "public utilities"		"railway applications" or noise or external or factory or "industrial facilities" or "industrial facility" or "business facilities" or "business facility" or enterprise* or "administrative facilities" or consumer or services or "public services"	Not required at present	"circular economy" or "material efficiency" or "sustainable procurement" or welfare or privacy or payback	Not required at present
		AND		AND		AND		AND		AND		AND		AND		AND		AND		AND
	Creation	Creation or Capture or Measur* or Monitor* or Observation	Creat* or Captur* or Measur* or Monitor* or Observ*	Origin (empty): 85 Origin: IX: 24	Creat* or Captur* or Measur* or Monitor* or Observ*	Origin (empty): 205 Origin: IX: 27	Creat* or Captur* or Measur* or Monitor* or Observ*	Origin (empty): 111 Origin: IX: 9	Creat* or Captur* or Measur* or Monitor* or Observ*	Origin (empty): 139 Origin: IX: 25	Creat* or Captur* or Measur* or Monitor* or Observ*	Origin (empty): 103 Origin: IX: 26	Creat* or Captur* or Measur* or Monitor* or Observ*	Origin (empty): 147 Origin: IX: 12	Creat* or Captur* or Measur* or Monitor* or Observ*	Origin (empty): 19 Origin: IX: 4	Creat* or Captur* or Measur* or Monitor* or Observ*	Origin (empty): Origin: IX:	Creat* or Captur* or Measur* or Monitor* or Observ*	Origin (empty): Origin: IX:
	Search/Publish	search or publish or Catalogue or Metadata or Discover or Archive or handling	search* or publish* or Catalogu* or Metadata or Discover* or Archiv* or handl*	Origin (empty): 26 Origin: IX: 4	search* or publish* or Catalogu* or Metadata or Discover* or Archiv* or handl*	Origin (empty): 134 Origin: IX: 11	search* or publish* or Catalogu* or Metadata or Discover* or Archiv* or handl*	Origin (empty): 26 Origin: IX: 4	search* or publish* or Catalogu* or Metadata or Discover* or Archiv* or handl*	Origin (empty): 58 Origin: IX: 6	search* or publish* or Catalogu* or Metadata or Discover* or Archiv* or handl*	Origin (empty): 63 Origin: IX: 3	search* or publish* or Catalogu* or Metadata or Discover* or Archiv* or handl*	Origin (empty): 46 Origin: IX: 2	search* or publish* or Catalogu* or Metadata or Discover* or Archiv* or handl*	Origin (empty): 14 Origin: IX: 0	search* or publish* or Catalogu* or Metadata or Discover* or Archiv* or handl*	Origin (empty): Origin: IX:	search* or publish* or Catalogu* or Metadata or Discover* or Archiv* or handl*	Origin (empty): Origin: IX:
	Format/Product	format or product or Structure or structural or "Content Model*" or Encod* or Schema	format* or product or Structure or structural or "Content Model*" or Encod* or Schema	Origin (empty): 84 Origin: IX: 13	format* or product or Structure or structural or "Content Model*" or Encod* or Schema	Origin (empty): 572 Origin: IX: 74	format* or product or Structure or structural or "Content Model*" or Encod* or Schema	Origin (empty): 165 Origin: IX: 24	format* or product or Structure or structural or "Content Model*" or Encod* or Schema	Origin (empty): 164 Origin: IX: 20	format* or product or Structure or structural or "Content Model*" or Encod* or Schema	Origin (empty): 407 Origin: IX: 64	format* or product or Structure or structural or "Content Model*" or Encod* or Schema	Origin (empty): 165 Origin: IX: 14	format* or product or Structure or structural or "Content Model*" or Encod* or Schema	Origin (empty): 13 Origin: IX: 1	format* or product or Structure or structural or "Content Model*" or Encod* or Schema	Origin (empty): Origin: IX:	format* or product or Structure or structural or "Content Model*" or Encod* or Schema	Origin (empty): Origin: IX:
	Exchange	exchang* or communicat* or Interoperability or interchange or transmission or transmit* or network*	exchang* or communicat* or Interoperability or interchange or transmission or transmit* or network*	Origin (empty): 227 Origin: IX: 54	exchang* or communicat* or Interoperability or interchange or transmission or transmit* or network*	Origin (empty): 1543 Origin: IX: 268	exchang* or communicat* or Interoperability or interchange or transmission or transmit* or network*	Origin (empty): 494 Origin: IX: 97	exchang* or communicat* or Interoperability or interchange or transmission or transmit* or network*	Origin (empty): 571 Origin: IX: 93	exchang* or communicat* or Interoperability or interchange or transmission or transmit* or network*	Origin (empty): 1040 Origin: IX: 125	exchang* or communicat* or Interoperability or interchange or transmission or transmit* or network*	Origin (empty): 629 Origin: IX: 97	exchang* or communicat* or Interoperability or interchange or transmission or transmit* or network*	Origin (empty): 80 Origin: IX: 9	exchang* or communicat* or Interoperability or interchange or transmission or transmit* or network*	Origin (empty): Origin: IX:	exchang* or communicat* or Interoperability or interchange or transmission or transmit* or network*	Origin (empty): Origin: IX:
	Analysis	analys* or analyz* or Visualis* or visualiz*or Portrayal or "Error Handling"	analys* or analyz* or Visualis* or visualiz*or Portrayal or "Error Handling"	Origin (empty): 22 Origin: IX: 0	analys* or analyz* or Visualis* or visualiz*or Portrayal or "Error Handling"	Origin (empty): 39 Origin: IX: 0	analys* or analyz* or Visualis* or visualiz*or Portrayal or "Error Handling"	Origin (empty): 30 Origin: IX: 0	analys* or analyz* or Visualis* or visualiz*or Portrayal or "Error Handling"	Origin (empty): 30 Origin: IX: 0	analys* or analyz* or Visualis* or visualiz*or Portrayal or "Error Handling"	Origin (empty): 19 Origin: IX: 0	analys* or analyz* or Visualis* or visualiz*or Portrayal or "Error Handling"	Origin (empty): 80 Origin: IX: 0	analys* or analyz* or Visualis* or visualiz*or Portrayal or "Error Handling"	Origin (empty): 3 Origin: IX: 0	analys* or analyz* or Visualis* or visualiz*or Portrayal or "Error Handling"	Origin (empty): Origin: IX:	analys* or analyz* or Visualis* or visualiz*or Portrayal or "Error Handling"	Origin (empty): Origin: IX:
	Management	manag* or Lifecycle* or Audit* or Security or reuse or reusing or reused or destruction or Quality or "Life cycles" or "life cycle" or destroy*	manag* or Lifecycle* or Audit* or Security or reuse or reusing or reused or destruction or Quality or "Life cycles" or "life cycle" or destroy*	Origin (empty): 239 Origin: IX: 18	manag* or Lifecycle* or Audit* or Security or reuse or reusing or reused or destruction or Quality or "Life cycles" or "life cycle" or destroy*	Origin (empty): 817 Origin: IX: 51	manag* or Lifecycle* or Audit* or Security or reuse or reusing or reused or destruction or Quality or "Life cycles" or "life cycle" or destroy*	Origin (empty): 137 Origin: IX: 17	manag* or Lifecycle* or Audit* or Security or reuse or reusing or reused or destruction or Quality or "Life cycles" or "life cycle" or destroy*	Origin (empty): 348 Origin: IX: 28	manag* or Lifecycle* or Audit* or Security or reuse or reusing or reused or destruction or Quality or "Life cycles" or "life cycle" or destroy*	Origin (empty): 339 Origin: IX: 25	manag* or Lifecycle* or Audit* or Security or reuse or reusing or reused or destruction or Quality or "Life cycles" or "life cycle" or destroy*	Origin (empty): 307 Origin: IX: 31	manag* or Lifecycle* or Audit* or Security or reuse or reusing or reused or destruction or Quality or "Life cycles" or "life cycle" or destroy*	Origin (empty): 46 Origin: IX: 7	manag* or Lifecycle* or Audit* or Security or reuse or reusing or reused or destruction or Quality or "Life cycles" or "life cycle" or destroy*	Origin (empty): Origin: IX:	manag* or Lifecycle* or Audit* or Security or reuse or reusing or reused or destruction or Quality or "Life cycles" or "life cycle" or destroy*	Origin (empty): Origin: IX:

6.2.2 Transport

	"Transport* station*"	No. of Hits	"Transport* Hub"	No. of Hits	"Buildings open to the public"	No. of Hits	"Railway Station"	No. of Hits	"Smart station*"	No. of Hits	"Intelligent Transport Systems"	No. of Hits	"Smart motorways"	No. of Hits	"Smart cit*"	No. of Hits	Road	No. of Hits	Traffic	No. of Hits
Service 1	"Manag*" OR "control*" OR "passenger*" OR "decision-making" OR " users" OR " journey*" OR "rout*" OR "traveller*" OR "trip*" OR "citizen*" OR "centre*" OR "center*" OR "directions" OR "dynamic" OR "flow" OR "adaptative" OR "density" OR "wayfinding" OR "walk*"	6 (Origin:Empty) 36 1 (Origin:IX) 3	Manag* OR control* OR passenger* OR "decision making" OR users OR user OR journey* OR rout* OR traveller* OR traveler OR trip* OR citizen* OR centre* OR center* OR directions OR direction OR dynamic OR flow OR adaptative OR density OR wayfinding OR "way finding" OR walk*	0 (Origin:Empty) 0 (Origin:IX)	Manag* OR control* OR passenger* OR "decision making" OR users OR user OR journey* OR rout* OR traveller* OR traveler OR trip* OR citizen* OR centre* OR center* OR directions OR direction OR dynamic OR flow OR adaptative OR density OR wayfinding OR "way finding" OR walk*	296 (Origin:Empty) 896 4 (Origin:IX)	Manag* OR control* OR passenger* OR "decision making" OR users OR user OR journey* OR rout* OR traveller* OR traveler OR trip* OR citizen* OR centre* OR center* OR directions OR direction OR dynamic OR flow OR adaptative OR density OR wayfinding OR "way finding" OR walk*	8 (Origin:Empty) 17 0 (Origin:IX) 3	Manag* OR control* OR passenger* OR "decision making" OR users OR user OR journey* OR rout* OR traveller* OR traveler OR trip* OR citizen* OR centre* OR center* OR directions OR direction OR dynamic OR flow OR adaptative OR density OR wayfinding OR "way finding" OR walk*	0 (Origin:Empty) 0 (Origin:IX)	"real time" OR "traffic flow" OR "control centre*" OR "control center*" OR "on-trip" OR "traffic data" OR "dynamic" OR "traffic statistics" OR "traffic monitor*" OR "traffic condition*" OR "level of service" OR "traffic classification" OR "traveller information service*" OR "travel information system*"	21 (Origin:Empty) 1 (Origin:IX)	"real time" OR "traffic flow" OR "control centre*" OR "control center*" OR "on-trip" OR "traffic data" OR "dynamic" OR "traffic statistics" OR "traffic monitor*" OR "traffic condition*" OR "level of service" OR "traffic classification" OR "traveller information service*" OR "travel information system*"	0 (Origin:Empty) 0 (Origin:IX)	"real time" OR "traffic flow" OR "control centre*" OR "control center*" OR "on-trip" OR "traffic data" OR "dynamic" OR "traffic statistics" OR "traffic monitor*" OR "traffic condition*" OR "level of service" OR "traffic classification" OR "traveller information service*" OR "travel information system*"	0 (Origin:Empty) 0 (Origin:IX)	"real time" OR "traffic flow" OR "control centre*" OR "control center*" OR "on-trip" OR "traffic data" OR "dynamic" OR "traffic statistics" OR "traffic monitor*" OR "traffic condition*" OR "level of service" OR "traffic classification" OR "traveller information service*" OR "travel information system*"	199 (Origin:Empty) 197 1 (Origin:IX)	"real time" OR "traffic flow" OR "control centre*" OR "control center*" OR "on-trip" OR "traffic data" OR "dynamic" OR "traffic statistics" OR "traffic monitor*" OR "traffic condition*" OR "level of service" OR "traffic classification" OR "traveller information service*" OR "travel information system*"	195 (Origin:Empty) 15 (Origin:IX)
Service 2	"Provision" OR "Free-flow" OR "ticket*" OR "supply" OR "smart" OR "seamless" OR "payment" OR "wireless" OR "passengers"	1 (Origin:Empty) 6 1 (Origin:IX) 2	"Provision" OR "Free-flow" OR "ticket*" OR "supply" OR "smart" OR "seamless" OR "payment" OR "wireless" OR "passengers"	0 (Origin:Empty) 0 (Origin:IX)	"Provision" OR "Free-flow" OR "ticket*" OR "supply" OR "smart" OR "seamless" OR "payment" OR "wireless" OR "passengers"	251 (Origin:Empty) 391 4 (Origin:IX)	"Provision" OR "Free-flow" OR "ticket*" OR "supply" OR "smart" OR "seamless" OR "payment" OR "wireless" OR "passengers"	6 (Origin:Empty) 0 (Origin:IX)	"Provision" OR "Free-flow" OR "ticket*" OR "supply" OR "smart" OR "seamless" OR "payment" OR "wireless" OR "passengers"	0 (Origin:Empty) 0 (Origin:IX)	"Dynamic" OR "MIDAS" OR "real-time" OR "traffic sign*" OR "Traffic technolog*" OR "telematics" OR "rout*" "journey*" OR "VMS" OR "road vehicles" OR "messag*" OR "adaptative"	69 (Origin:Empty) 74 3 (Origin:IX) 4	"Dynamic" OR "MIDAS" OR "real-time" OR "traffic sign*" OR "Traffic technolog*" OR "telematics" OR "rout*" "journey*" OR "VMS" OR "road vehicles" OR "messag*" OR "adaptative"	0 (Origin:Empty) 0 (Origin:IX)	"Dynamic" OR "MIDAS" OR "real-time" OR "traffic sign*" OR "Traffic technolog*" OR "telematics" OR "rout*" "journey*" OR "VMS" OR "road vehicles" OR "messag*" OR "adaptative"	3 (Origin:Empty) 0 (Origin:IX)	"Dynamic" OR "MIDAS" OR "real-time" OR "traffic sign*" OR "Traffic technolog*" OR "telematics" OR "rout*" "journey*" OR "VMS" OR "road vehicles" OR "messag*" OR "adaptative"	6615 (Origin:Empty) 6521 258 (Origin:IX) 264	"Dynamic" OR "MIDAS" OR "real-time" OR "traffic sign*" OR "Traffic technolog*" OR "telematics" OR "rout*" "journey*" OR "VMS" OR "road vehicles" OR "messag*" OR "adaptative"	653 (Origin:Empty) 659 103 (Origin:IX) 104

6.2.3 Utilities

Keyword ->	Smart cities or smart city	No. of hits	Smart grid or smart grids	No. of hits	Electricity OR "Power transmission" (excluded from search due to 1783 hits) OR "distribution network*"	No. of hits	"Micro grid"	No. of hits	Smart buildings or Smart building	No. of hits
Service 1	"energy manag*" OR "load management" OR "load forecasting" OR "load control*" OR "control centre*" OR "control center*" OR "forecasting" OR "energy demand" OR "load" OR "energy" OR " level of service" OR "information" OR "energy consumption data" OR "available capacity data" OR "consumption profile data" OR "environmental data" OR "demand management" OR "demand-side response" OR "edge balancing" OR "management of DSR data"	26 (Origin:Empty) 2 (Origin:IX)	"energy manag*" OR "load management" OR "load forecasting" OR "load control*" OR "control centre*" OR "forecasting" OR "energy demand" OR "load" OR "energy" OR " level of service" OR "information" OR "energy consumption data" OR "available capacity data" OR "consumption profile data" OR "environmental data" OR "demand management" OR "demand-side response" OR "edge balancing" OR "management of DSR data"	59 (Origin:Empty) 67 0 (Origin:IX) 2	"energy manag*" OR "load management" OR "load forecasting" OR "load control*" OR "control centre*" OR "forecasting" OR "energy demand" OR "load" OR "energy" OR " level of service" OR "information" OR "energy consumption data" OR "available capacity data" OR "consumption profile data" OR "environmental data" OR "demand management" OR "demand-side response" OR "edge balancing" OR "management of DSR data"	1298 (Origin:Empty) 1306 48 (Origin:IX)	"energy manag*" OR "load management" OR "load forecasting" OR "load control*" OR "control centre*" OR "forecasting" OR "energy demand" OR "load" OR "energy" OR " level of service" OR "information" OR "energy consumption data" OR "available capacity data" OR "consumption profile data" OR "environmental data" OR "demand management" OR "demand-side response" OR "edge balancing" OR "management of DSR data"	0 (Origin:Empty) 6 0 (Origin:IX)	"energy manag*" OR "load management" OR "load forecasting" OR "load control*" OR "control centre*" OR "control center*" OR forecasting OR "energy demand" OR load OR energy OR " level of service" OR "information" OR "energy consumption data" OR "available capacity data" OR "consumption profile data" OR "environmental data" OR "demand management" OR "demand-side response" OR "edge balancing" OR "management of DSR data"	19 (Origin:Empty) 20 2(Origin:IX)
Service 2	"Management of" OR "control centre*" OR "control center*" OR "forecasting" OR "peak load" OR "intelligent appliance*" OR "smart appliance*" OR "household equipment*" OR "small business" OR "demand" OR "peak" OR "supply management" OR "supply provision" OR "frequency response reserve" OR "reserve" OR "demand management" OR "behind the meter"	1 (Origin:Empty) 0 (Origin:IX)	"Management of" OR "control centre*" OR "control center*" OR "forecasting" OR "peak load" OR "intelligent appliance*" OR "smart appliance*" OR "household equipment*" OR "small business" OR "demand" OR "peak" OR "supply management" OR "supply provision" OR "frequency response reserve" OR "reserve" OR "demand management" OR "behind the meter"	2 (Origin:Empty) 4 0 (Origin:IX)	"Management of" OR "control centre*" OR "control center*" OR "forecasting" OR "peak load" OR "intelligent appliance*" OR "smart appliance*" OR "household equipment*" OR "small business" OR "demand" OR "peak" OR "supply management" OR "supply provision" OR "frequency response reserve" OR "reserve" OR "demand management" OR "behind the meter"	296 (Origin:Empty) 256 19 (Origin:IX)	"Management of" OR "control centre*" OR "control center*" OR "forecasting" OR "peak load" OR "intelligent appliance*" OR "smart appliance*" OR "household equipment*" OR "small business" OR "demand" OR "peak" OR "supply management" OR "supply provision" OR "frequency response reserve" OR "reserve" OR "demand management" OR "behind the meter"	0 (Origin:Empty) 0 (Origin:IX)	"Management of" OR "control centre*" OR "control center*" OR "forecasting" OR "peak load" OR "intelligent appliance*" OR "smart appliance*" OR "household equipment*" OR "small business" OR "demand" OR "peak" OR "supply management" OR "supply provision" OR "frequency response reserve" OR "reserve" OR "demand management" OR "behind the meter"	1 (Origin:Empty) 0 (Origin:IX)

6.2.4 Housing

	Housing											
	"Residential"		"Domestic"		"Design"		"architect*"		"structur*"		"engineer*"	
	AND	No. of Results	AND	No. of Results	AND	No. of Results	AND	No. of Results	AND	No. of Results	AND	
Service 1: To provide safer, more accessible and affordable social housing.	"house" OR "houses" OR "housing" OR "access" OR "accessibility" OR "afford*" OR "cost*" OR "tenant" OR "landlord" OR "social" OR "citizen*" OR "Fire safety in buildings" OR "Means of escape from fire in buildings" OR "emergency exits" OR "Fire-escape routes" OR "management" OR "Lifts" OR "Risk assessment" OR "Fire doors" OR "Fire-resistant materials" OR "Buildings by fire risk categories" OR "Fire safety" OR "Fire alarms" OR "Disabled people"	ALL: 384 IX : 0	"house" OR "houses" OR "housing" OR "access" OR "accessibility" OR "afford*" OR "cost*" OR "tenant" OR "landlord" OR "social" OR "citizen*" OR "Fire safety in buildings" OR "Means of escape from fire in buildings" OR "emergency exits" OR "Fire-escape routes" OR "management" OR "Lifts" OR "Risk assessment" OR "Fire doors" OR "Fire-resistant materials" OR "Buildings by fire risk categories" OR "Fire safety" OR "Fire alarms" OR "Disabled people"	ALL: 500 IX : 1	"house" OR "houses" OR "housing" OR "access" OR "accessibility" OR "afford*" OR "cost*" OR "tenant" OR "landlord" OR "social" OR "citizen*" OR "Fire safety in buildings" OR "Means of escape from fire in buildings" OR "emergency exits" OR "Fire-escape routes" OR "management" OR "Lifts" OR "Risk assessment" OR "Fire doors" OR "Fire-resistant materials" OR "Buildings by fire risk categories" OR "Fire safety" OR "Fire alarms" OR "Disabled people"	ALL: 1313 IX : 23	"house" OR "houses" OR "housing" OR "access" OR "accessibility" OR "afford*" OR "cost*" OR "tenant" OR "landlord" OR "social" OR "citizen*" OR "Fire safety in buildings" OR "Means of escape from fire in buildings" OR "emergency exits" OR "Fire-escape routes" OR "management" OR "Lifts" OR "Risk assessment" OR "Fire doors" OR "Fire-resistant materials" OR "Buildings by fire risk categories" OR "Fire safety" OR "Fire alarms" OR "Disabled people"	ALL: 172 IX : 0	"house" OR "houses" OR "housing" OR "access" OR "accessibility" OR "afford*" OR "cost*" OR "tenant" OR "landlord" OR "social" OR "citizen*" OR "Fire safety in buildings" OR "Means of escape from fire in buildings" OR "emergency exits" OR "Fire-escape routes" OR "management" OR "Lifts" OR "Risk assessment" OR "Fire doors" OR "Fire-resistant materials" OR "Buildings by fire risk categories" OR "Fire safety" OR "Fire alarms" OR "Disabled people"	ALL: 1430 IX : 42	"house" OR "houses" OR "housing" OR "access" OR "accessibility" OR "afford*" OR "cost*" OR "tenant" OR "landlord" OR "social" OR "citizen*" OR "Fire safety in buildings" OR "Means of escape from fire in buildings" OR "emergency exits" OR "Fire-escape routes" OR "management" OR "Lifts" OR "Risk assessment" OR "Fire doors" OR "Fire-resistant materials" OR "Buildings by fire risk categories" OR "Fire safety" OR "Fire alarms" OR "Disabled people"	ALL: 742 IX : 37
Service 2: To build energy efficient housing more quickly.	"Efficiency" OR "Thermal output" OR "Heat" OR "Water heaters" OR "Heat transfer" OR "Heat loss" OR "Heat pumps" OR "Energy consumption" OR "Hot-water supply systems" OR "Thermal environment systems" OR "Space-heating systems" OR "Heating equipment" OR "energ*" OR "insulat*" OR "Engineering drawings" OR "Architectural drawings" OR "Drawings" OR "Technical drawing" OR "Graphic representation" OR "Lines (geometry)" OR "Construction systems parts" OR "Technical documents" OR "Building specifications" OR "Space planning and design"	ALL: 506 IX : 3	"Efficiency" OR "Thermal output" OR "Heat" OR "Water heaters" OR "Heat transfer" OR "Heat loss" OR "Heat pumps" OR "Energy consumption" OR "Hot-water supply systems" OR "Thermal environment systems" OR "Space-heating systems" OR "Heating equipment" OR "energ*" OR "insulat*" OR "Engineering drawings" OR "Architectural drawings" OR "Drawings" OR "Technical drawing" OR "Graphic representation" OR "Lines (geometry)" OR "Construction systems parts" OR "Technical documents" OR "Building specifications" OR "Space planning and design"	ALL: 653 IX : 2	"Efficiency" OR "Thermal output" OR "Heat" OR "Water heaters" OR "Heat transfer" OR "Heat loss" OR "Heat pumps" OR "Energy consumption" OR "Hot-water supply systems" OR "Thermal environment systems" OR "Space-heating systems" OR "Heating equipment" OR "energ*" OR "insulat*" OR "Engineering drawings" OR "Architectural drawings" OR "Drawings" OR "Technical drawing" OR "Graphic representation" OR "Lines (geometry)" OR "Construction systems parts" OR "Technical documents" OR "Building specifications" OR "Space planning and design"	ALL: 1686 IX : 29	"Efficiency" OR "Thermal output" OR "Heat" OR "Water heaters" OR "Heat transfer" OR "Heat loss" OR "Heat pumps" OR "Energy consumption" OR "Hot-water supply systems" OR "Thermal environment systems" OR "Space-heating systems" OR "Heating equipment" OR "energ*" OR "insulat*" OR "Engineering drawings" OR "Architectural drawings" OR "Drawings" OR "Technical drawing" OR "Graphic representation" OR "Lines (geometry)" OR "Construction systems parts" OR "Technical documents" OR "Building specifications" OR "Space planning and design"	ALL: 336 IX : 1	"Efficiency" OR "Thermal output" OR "Heat" OR "Water heaters" OR "Heat transfer" OR "Heat loss" OR "Heat pumps" OR "Energy consumption" OR "Hot-water supply systems" OR "Thermal environment systems" OR "Space-heating systems" OR "Heating equipment" OR "energ*" OR "insulat*" OR "Engineering drawings" OR "Architectural drawings" OR "Drawings" OR "Technical drawing" OR "Graphic representation" OR "Lines (geometry)" OR "Construction systems parts" OR "Technical documents" OR "Building specifications" OR "Space planning and design"	ALL: 1816 IX : 56	"Efficiency" OR "Thermal output" OR "Heat" OR "Water heaters" OR "Heat transfer" OR "Heat loss" OR "Heat pumps" OR "Energy consumption" OR "Hot-water supply systems" OR "Thermal environment systems" OR "Space-heating systems" OR "Heating equipment" OR "energ*" OR "insulat*" OR "Engineering drawings" OR "Architectural drawings" OR "Drawings" OR "Technical drawing" OR "Graphic representation" OR "Lines (geometry)" OR "Construction systems parts" OR "Technical documents" OR "Building specifications" OR "Space planning and design"	ALL: 1193 IX : 47

6.2.5 Health

Search 1

Your query - Health
without: Document identifier+: "EN" OR "ISO" OR "IEC" OR "TS" OR "TR" OR "CEN" OR “CIE” OR "DSF" ,
without: Title/Keywords (English): "Addendum" OR "amendment" OR "Corrigendum" OR "Erratum",
and Title (English): Health or healthcare or "Ambient Assisted Living" ,
and Title/Keywords (English): elderly OR outcome* OR benefit* OR care OR caring OR plan* OR deliver* OR triag* OR Convales* OR patient* OR acute OR framework* OR rehabilitat* OR chronic* OR social* OR communit* OR capacit* OR capabilit* OR discharge* OR administ* OR admit* OR emergenc* OR assist* OR "Ambient Assisted Living" or Sanatorium or "nursing home*",
without: Document identifier+: "AMD" OR "AC" OR "A1" OR "A2" OR "A3" OR "A4" OR "A5" OR "A6" OR "A7" OR "A8" OR "A9" OR "A10" OR "A11" OR "A12" OR "PRA1" OR "PRA2" OR "PRA3" OR "PRA4" OR "PRA5" OR "PRA6" OR "HD" OR "UIC" OR "CWA" OR "AGFW" OR "VDI" OR "VDMA" OR "ITU*" OR "ASD-STAN" OR "EN" OR "ISO" OR "IEC" OR "TS" OR "TR" OR "CEN" OR "CIE" OR "DSF",
Only valid records resulted in 671 hits.

Search 2

Your query - Health
Origin code: "IX",
without Title/Keywords (English): "Addendum" OR "amendment" OR "Corrigendum" OR "Erratum",
and Title (English): Health or healthcare or "Ambient Assisted Living" ,
and Title/Keywords (English): elderly OR outcome* OR benefit* OR care OR caring OR plan* OR deliver* OR triag* OR Convales* OR patient* OR acute OR framework* OR rehabilitat* OR chronic* OR social* OR communit* OR capacit* OR capabilit* OR discharge* OR administ* OR admit* OR emergenc* OR assist* OR "Ambient Assisted Living" or Sanatorium or "nursing home*",
without Document identifier+: "AMD" OR "AC" OR "A1" OR "A2" OR "A3" OR "A4" OR "A5" OR "A6" OR "A7" OR "A8" OR "A9" OR "A10" OR "A11" OR "A12" OR "PRA1" OR "PRA2" OR "PRA3" OR "PRA4" OR "PRA5" OR "PRA6" OR "HD" OR "UIC" OR "CWA" OR "AGFW" OR "VDI" OR "VDMA" OR "ITU*" OR "ASD-STAN" OR "EN" OR "ISO" OR "IEC" OR "TS" OR "TR" OR "CEN" OR "CIE" OR "DSF",
Only valid records resulted in 124 hits.

Search 1

Your query - Hospital Bed
without Document identifier+: "EN" OR "ISO" OR "IEC" OR "TS" OR "TR" OR "CEN" OR “CIE” OR "DSF" ,
without Title/Keywords (English): "Addendum" OR "amendment" OR "Corrigendum" OR "Erratum",
and Free text: hospital* and bed*,
and Free text: manag* OR block* OR discharg* OR administ* OR capacit*,
without Document identifier+: "AMD" OR "AC" OR "A1" OR "A2" OR "A3" OR "A4" OR "A5" OR "A6" OR "A7" OR "A8" OR "A9" OR "A10" OR "A11" OR "A12" OR "PRA1" OR "PRA2" OR "PRA3" OR "PRA4" OR "PRA5" OR "PRA6" OR "HD" OR "UIC" OR "CWA" OR "AGFW" OR "VDI" OR "VDMA" OR "ITU*" OR "ASD-STAN" OR "EN" OR "ISO" OR "IEC" OR "TS" OR "TR" OR "CEN" OR "CIE" OR "DSF",
Only valid records resulted in 29 hits.

Search 2

Your query - Hospital Bed
Origin code: "IX"
without Title/Keywords (English): "Addendum" OR "amendment" OR "Corrigendum" OR "Erratum",
and Free text: hospital* and bed*,
and Free text: manag* OR block* OR discharge* OR administ* OR capacit*,
without Document identifier+: "AMD" OR "AC" OR "A1" OR "A2" OR "A3" OR "A4" OR "A5" OR "A6" OR "A7" OR "A8" OR "A9" OR "A10" OR "A11" OR "A12" OR "PRA1" OR "PRA2" OR "PRA3" OR "PRA4" OR "PRA5" OR "PRA6" OR "HD" OR "UIC" OR "CWA" OR "AGFW" OR "VDI" OR "VDMA" OR "ITU*" OR "ASD-STAN" OR "EN" OR "ISO" OR "IEC" OR "TS" OR "TR" OR "CEN" OR "CIE" OR "DSF",
Only valid records resulted in 0 hits.

Part 2 – Meta Standard

Digital Built Britain has a broad scope and the activities related to it amount to 43% of the UK's economy. In consequence, the number of actors linked to the built environment spans city mayors and officials, city planners, transport authorities, utilities service providers, design and engineering consultancies, construction companies, asset managers, facilities managers, building regulation authorities, hospital trusts, and government departments, to name a few.
In the journey towards a more integrated built environment able to address all the competing needs of different systems, a meta standard proposes an approach to begin to consolidate the needs and requirements of the asset into accessible, functional tools founded on the knowledge codified in standards, and augmented with best practice specifications, guidance and tools used by expert practitioners.
The meta standard approach enables the Convergence principle to come to life by developing use case informed tools. These provide the user with all the requirements relevant to the asset in a way that can be easily specified, while ensuring a full lifecycle picture is given.

7 Future of a DBB Meta Standard - Introduction

7.1 Meta standard

The meta standard toolkit was created by Dr Lluïsa Marsal as a methodology for integrating standards with a particular user in mind. The proof of concept meta standard integrated the Smart City standard with BIM and IoT standards. The intended user for this meta standard were mainly city planners.

The purpose of a meta standard can be summarised in the context of DBB, in the following points:

- Create an integration layer for the standards across the lifecycle of assets that refer to information requirements in particular, across the different stages of the lifecycle. This will therefore provide a comprehensive picture of the requirements across all stages.
- Support actors across the different groups, to plan, design, build, maintain, and operate with tools to ensure they are taking into account all the requirements downstream. This will enable them to future proof the specification, creation, use and feedback of information about an asset and its performance.
- Support individuals to carry out their work in a more informed way with a set of tools that help navigate the requirements for an information enabled built environment, and develop data driven tools that can support self-certification in the future.

Key characteristics of a meta standard are:

- It is user specific: while a whole lifecycle view can be provided, the meta standard base will dictate to a large extent which users or actors will find it most useful. By building the meta standard on the Smart Cities standards, the meta standard becomes geared towards supporting city infrastructure planners, while using the Asset management standards as the blueprint provides a useful tool to the asset manager or asset owner.

- It is competency led: the meta standard sets out a number of competencies that need to be fulfilled in order to ensure all aspects of the asset planning or asset maintenance have been met. In developing the meta standard further, we have considered the potential for increased scale and scope. The competency approach enables us to generalise these, whether we are considering a city scale development or a single building. To contextualise this within an organisation, where organisation could be a nation, city, local authority or campus, there should be a strategic framework which links the different aspects of the organisation together.
- It comprises different pathways: currently, these pathways include strategy, data/information, technology and finance. While these are key pathways to ensure a comprehensive assessment of the requirements for an asset in each stage of the lifecycle, we believe that an **Asset Capability pathway** needs to be explicitly developed, highlighting the performance requirements of the asset in question. This is challenging for the 'city view' given its complexity, but a necessity at least at system level (for example, energy, transport, health) to ensure that the DBB vision can be realised. The asset capability would describe the functionality of the asset, which responds to the service that is seeks to provide. This capability would be accompanied by the requirements for the service provision, which invariably would include the organisational requirements and employee requirements to fulfil the function.

7.2 L2C approach

As seen in the DBB Standards Landscape, there are thousands of standards relevant to the management of information and the built environment. However, these standards are not always accessible to the right person. This can be as a result of:

- Lack of relevant knowledge and capability: one of the biggest challenges faced by public clients, and local authorities in particular, is the lack of technical understanding of new data driven solutions and technologies. This can have a big impact in how services are initially procured and therefore their ultimate performance when services are delivered.
- Lack of understanding of downstream and upstream activities: in order to deliver complex infrastructure or building projects, and the services these support, technical experts, architects, engineers, and service providers need to focus on the fine detail to ensure successful delivery. However, this can sometimes have a myopic effect in the way that interoperability across the lifecycle is served. Upstream activities need to be cognisant and take into account the requirement of information use and management downstream.
- Poor links established between the asset, the information about the asset and how this supports a particular business or societal benefit. While this analysis is often part of business cases to support a particular change, the standards don't support this link through the lifecycle and the pathway breaks down. This prevents a successful full lifecycle feedback loop of information to inform upstream activities in the lifecycle.

8 Building the meta standard

The meta standard toolkit was created by Dr Lluïsa Marsal as a methodology for integrating standards. The proof of concept meta standard integrated the Smart City standard with BIM and IoT standards. The intended user for this meta standard was city planners.

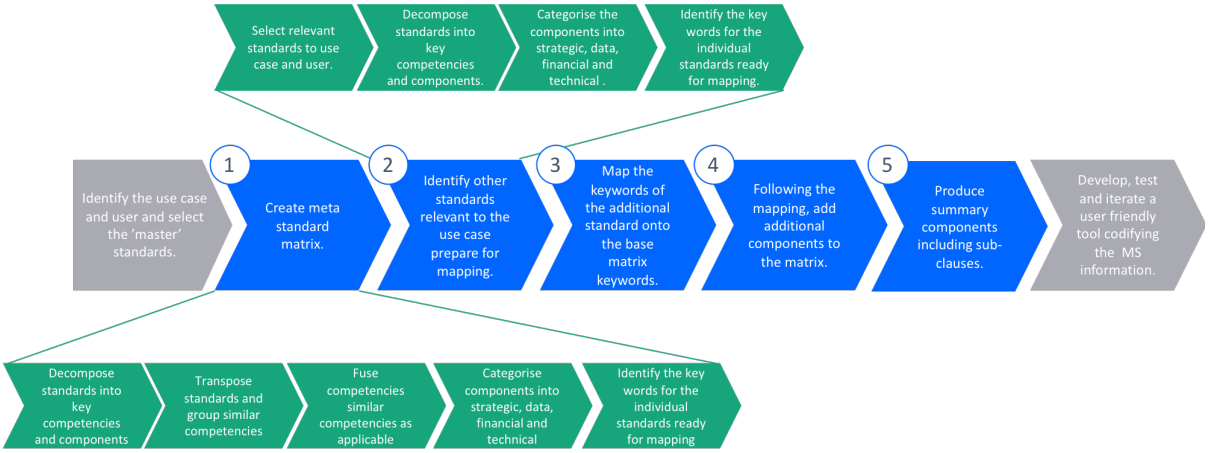


Figure 10 - Meta standards development process

8.1.1 Step 1 - Identifying the use case, user and master standards

As shown on Figure 10 the meta standard 'tool' could be adapted to different industries, levels of details or users. In this particular assignment we have focused on the meta standard tool required by city planners or city estates managers. This is a priority to explore because this role has a large impact in what is procured, whether during the capital phase or the operational phase.

8.1.2 Step 2 - Creating the matrix

The first step of the exercise was to review the asset management standards and apply the same methodology described in the Actionable Integrated Meta standard (AIM). The original meta standard took the four Smart City standards (PAS 181, PAS 182, PAS 183 and PAS 184) and analysed them individually, creating a matrix summary for each.

The standard competencies within the standard are identified along the top row which are a high-level description of the topics addressed and accounted for by the standard. The standard capabilities in the left-hand column are always the same in each standard and comprise the following:

- The need
- The strategy
- Recommendations

Standard components are then identified and categorised within this framework, as shown in Figure 11. As the different clauses of the standards are reviewed and analysed for mapping, they are also

categorised into strategy and vision (denoted in yellow), data and information (denoted in red), investment and expenditure (denoted in green) and technical and technological (in blue).

These categories are important, and will be explored later on. The master standards chosen to create the meta standard framework will generally be of a strategic nature (mostly yellow competencies). This colour coding also supports the user to quickly inspect the nature of standards, for example, BS 1192 part 2 is mostly red and PAS 212 is mostly blue when decomposed. An example of PAS 181 and 184 is shown in Figure 12. As expected these Smart Cities standards are of strategic nature almost in their entirety.

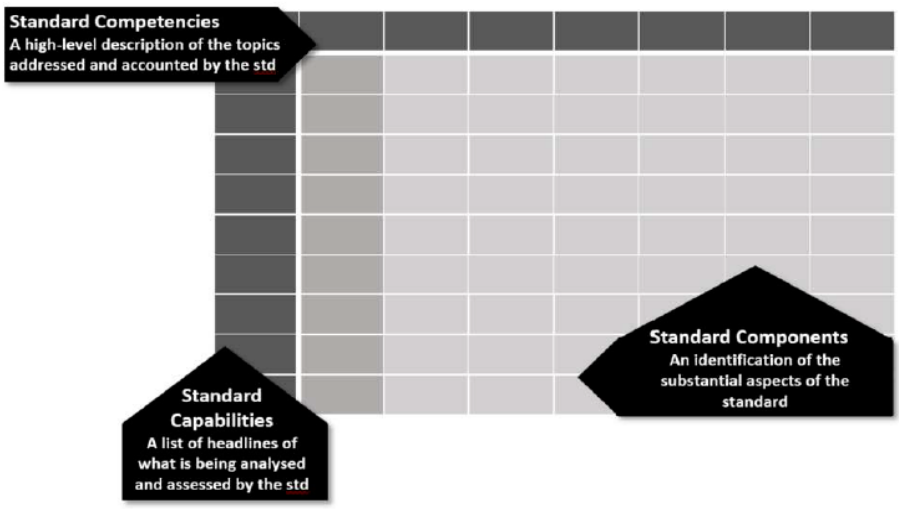


Figure 11 - conceptual architecture for the creation of a meta standard

Once the components were categorized it was easy to see what the prominent category was. It is evident from this exercise that PAS 181 and PAS 184 were primarily strategic and 182 and 183 were data focused.

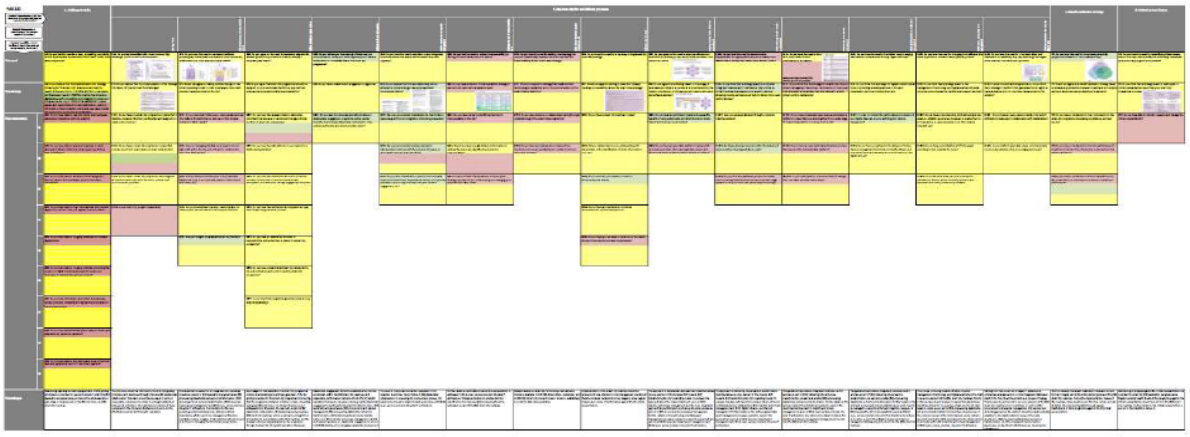


Figure 12: PAS 181 and 184 (Smart Cities meta standard)

8.1.3 Step 3 - Identify and prepare supplementary standards

The additional standards to supplement this meta standard are PAS 212 and BS1192 and the PAS 1192 series. These standards were decomposed into their competencies and principal components. The matrices of these standards were transposed but retain the principal components column as the 'transposition pillar'. Because there were competencies with converging guidance that could be

combined and allocated in one row, this process allowed the standards to be compacted next to the Principal Component they serve.

8.1.4 Step 4 – Keyword identification and mapping

A keyword mapping exercise is carried out to help identify the linkages between the standards. This helps to map the components of the supporting standards to the right component and competency of the master standards. An example of keyword mapping is shown below in Figure 13, completed for the original meta standard produced in March 2017:

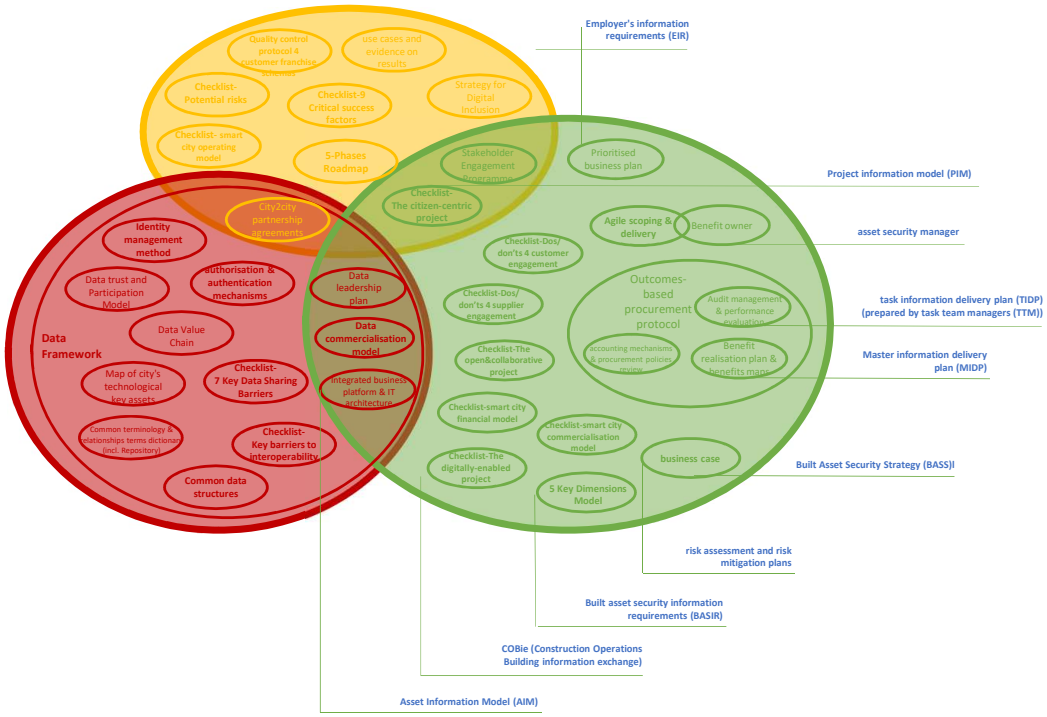


Figure 13 - Keyword mapping between Smart Cities matrix and 1192 series

8.1.5 Step 5 – Complete the meta standard

Having identified the linkages, the relevant components are integrated into the meta standard as shown in Figure 14. This is the final step in the development of the meta standard.

Figure 14 - original meta standard

9 CDBB Meta standard

9.1 Asset management Meta Standard framework

In this exercise we created a meta standard for interoperability between Asset management, BIM and IoT standards, applying the methodologies in the toolkit and creating a new user view: of the asset owner/manager.

9.1.1 Summarising the master standards and supplementary standards

Master Standards

The Asset Management meta standard framework is based on the ISO 55000 and ISO 55001 (instead of the PAS 18x series in the case of the Smart Cities view).

- ISO 55000 Asset management — Overview, principles and terminology
- IS0 55001 Asset management — Management systems — Requirements
- *ISO 55002 Asset management — Management systems — Guidelines for the application of ISO 55001 was not included in the master standards as the information provided within builds exactly on the same competencies put forward in 55001, providing more information in each section, and not relevant for the purpose of the meta standard.*

Supplementary standards

The supplementary standards to be included in this revision of the meta standard included the 1192 series and the PAS 212. The BIM suite, BS 1192, is composed of five volumes, two of which are BS (British Standard) and three are PAS (Publicly Available Specifications):

- BS 1192:2007 + A2:2016: Collaborative production of architectural, engineering and construction information – Code of practice.
- PAS 1192-2:2013: Specification for information management for the capital/delivery phase of construction projects using building information modelling.
- PAS 1192-3:2014: Specification for information management for the operational phase of assets using BIM.
- BS 1192-4:2014: Collaborative production of information. Fulfilling employer's information exchange requirements using COBie. Code of practice.
- PAS 1192-5:2015: Specification for security-minded building information modelling, digital built environments and smart asset management.

The IoT standard is a Publicly Available Specification integrated by a single volume:

- PAS 212:2016: Automatic resource discovery for the IoT. Specification.

Standards not included in this version:

A number of additional standards identified to be included in this meta standard to provide the right functionality to the user, are:

- BS 8536-1:2015: Briefing for design and construction. Code of practice for facilities management (Buildings infrastructure).
- BS 8536-2:2016: Design and construction: Code of practice for asset management (Linear and geographical infrastructure).
- BS 8587:2012: Guide to facility information management.
- ISO/TS 8000-150:2011: Data quality - Part 150: Master data: Quality management framework.
- BS 8210:2012: Guide to facilities maintenance management.
- ISO 41011:2017: Facility management – Vocabulary.
- ISO 41012:2017: Facility management – Guidance on strategic sourcing and the development of agreements.
- ISO/TR 41013:2017: Facility management – Scope, key concepts and benefits.
- ISO 41001: Facility management - Management systems - Requirements with guidance for use.

It is worth noting that ISO 55002 identifies a number of topics that can be considered in the context of the Asset management meta standard, depending on the use or user envisaged for it. The following non-exhaustive list is contained in Annex A of ISO 55002 and includes:

- Condition monitoring
- Risk management
- Quality management
- Environmental management
- Systems and software engineering
- Lifecycle costing
- Dependability (availability, reliability, maintainability, maintenance support)
- Configuration management
- Sustainable development
- Inspection

- Non-destructive testing
- Pressure equipment
- Financial management
- Value management
- Shock and vibration
- Acoustics
- Qualification and assessment of personnel
- Project management
- Property and property management
- Facilities management
- Equipment management
- Commissioning process
- Energy management

All of the above topics have a number of standards associated with them, both de jure and de facto, that can be linked to the meta standard. This detail mapping of de jure and de factor standards would create a comprehensive toolkit for a specific user, following the more strategic framework set out in the meta standard.

The decision to include more specific guidance into the meta standard needs to be carefully considered given that it would duplicate existing information. In this case it would be better to signpost to the relevant standard.

Where a competency from ISO 55000 aligns or complements a competency in the Actionable Integrated Standard, it has been copied alongside with a red border, as shown in Figure 19.

9.1.2 Building the Asset management meta standard

Here, the intention was to apply the same process with ISO 55000, ISO 55001 and ISO 55002 and then map PAS 212 and BSs and PASs 1192. However, the asset management standards are part of an interlinked series which are slightly different to the Smart City standards. Smart City standards overlap but are based on different subjects. Fusing ISO 55000, ISO 55001 and ISO 55002 in the same way makes little sense as each standard covers the same topics but in different levels of detail. The headings or standard competencies are the same throughout.

Instead of fusing the three standards, ISO 55000 and 55001 provide a high-level summary, covering the relevant competencies for the meta standard as well as the topics and keywords necessary. The Asset management meta standard matrix is created following the steps outlined in the following methodology:

Step 1- decomposition (as shown in Figure 22 - ISO 55000 decomposition

and

Figure 23.)

Step 2 – fusion of the master standard was straightforward as all the competencies were the same, with relatively similar levels of detail. The components of ISO 55000/55001 were summarised into one competency where applicable, creating one matrix, shown in **Error! Reference source not found.**.

Step 3 – key word identification and mapping as shown in **Error! Reference source not found.**, where key words are highlighted in purple. These keywords were then compared and mapped with keywords from the supplementary standards, as shown in Figure **Error! Unknown switch argument.**. The keywords from ISO 55000 form the circles of the diagram. The keywords from the other standards are then mapped to the key words identified in ISO 55000.

Step 4 and 5 – The meta standard matrix was then transposed to enable mapping of supplementary standards. The clauses can then be mapped to the relevant components as identified through the keyword mapping. The extract below, for example, shows components from different standards that are all relevant to the leadership competency. The 'roles and responsibilities' competency, under the Leadership section of ISO 55000, can be linked to the individual roles and responsibilities identified in BS1192, PASs 1192 and PAS 212.

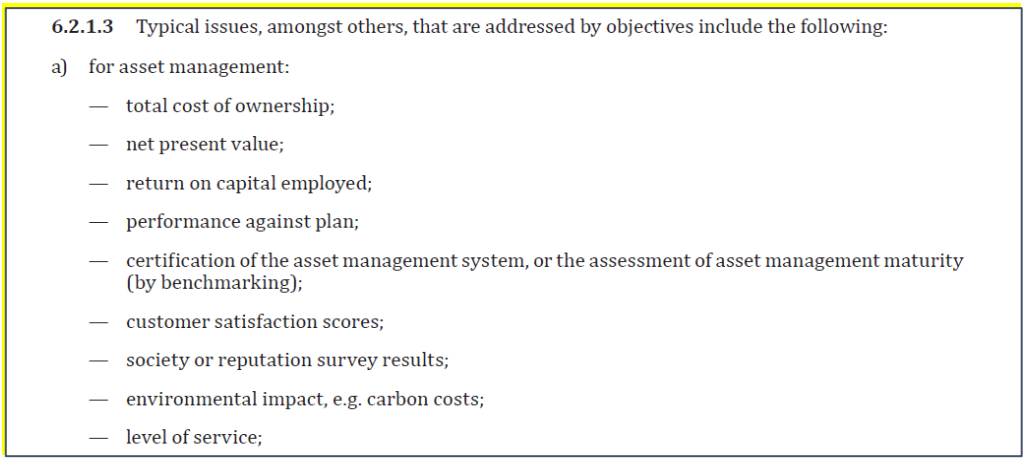
	Leadership and commitment from all managerial levels is essential for successfully establishing, operating and improving asset management within the organization. **Roles, responsibilities and authorities** should be clearly defined.Employees should be **aware, competent, and empowered**. Employees and stakeholders should be **consulted with** regarding asset management.		
6.1 Where the security triage process identifies a need for a security-minded approach, the employer or asset owner shall nominate a suitably qualified and experienced individual to fulfil the role of **built asset security manager**.	In accordance with ISO/TS 8000-150, **a data manager** should have the responsibility for accepting information into the shared area of the CDE and for authorizing it for the published area.	**Roles and responsibilities for information management as defined in this PAS** shall be set out in the **contract(s)** between the owner or operator and the maintainer(s).	PAS1192-2 Information Manager. Under the BIM Protocol, a client is obliged to appoint an information manager at all project stages.

Figure 15 - Extract from Asset management meta standard - leadership competency

9.1.3 Discussion

There are several gaps where none of the other standards map to the ISO 55000 components, such as in areas of 'operations', 'performance evaluation' or 'support'. Gaps in the matrix do not necessarily indicate a gap in content, as the strategic guidance may have been covered already. The design of this tool in its final state, would ensure subordinate clauses or standards are compliant with the guidance and standards offered in the parent document. This is currently very challenging, but would be feasible if the content of the standards was digitised and linked. However, for an

actionable toolkit, the meta standard needs to provide links to standards and clauses that are actionable. The clauses in ISO 55001 point to ISO 55002, which provides more detailed advice on how to implement the relevant competency. It is important to ensure that advice for implementation is provided or signposted to 'upstream' actors where guidance to define this information can be found. For example, for setting asset management objectives, ISO 55002 has additional advice identifying what these should include:



6.2.1.3 Typical issues, amongst others, that are addressed by objectives include the following:

a) for asset management:

- total cost of ownership;
- net present value;
- return on capital employed;
- performance against plan;
- certification of the asset management system, or the assessment of asset management maturity (by benchmarking);
- customer satisfaction scores;
- society or reputation survey results;
- environmental impact, e.g. carbon costs;
- level of service;

Figure 16 - extract from ISO 55002

Some gaps can be identified that would benefit from additional guidance in the form of data or technical clauses. For example, linking asset reports to financial reports could benefit from further guidance on lifecycle costing. Figure 16 provides an extract from the newly assembled meta standard, pointing to the need for aligning the asset and organisations objectives, linking both to the financial reporting.

Aligning the asset management objectives with the organizational objectives, as well as **linking asset reports to financial reports**, can improve the organization's effectiveness and efficiency, **The linking of asset reports to financial reports can also improve and clarify the assessment of the financial status and long-term funding requirements of the organization**

Figure 17 - Extract from 55000 Meta standard

In addition, some components request that asset data should be verified and consolidated. This would benefit from signposting in the relevant data management standards.

The a**sset management system** provides information to support the development of **asset management plans** and the evaluation of their effectiveness. Asset information systems can be extremely large and complex in some organizations, and there are many issues involved in collecting, **verifying and consolidating asset data** in order to transform it into asset information. Creating, controlling, and documenting this information is a critical function of the asset management system.

Figure 17 - Extract from 55000 Meta standard

It is possible to develop a meta standard framework for asset management as shown in this exercise. This framework needs to be further enhanced with specific guidance relevant to the use case at hand. This is further developed in WP6 as part of the demonstrator proposal.

9.2 Smart Cities meta standard integration

The original meta standard proof of concept, based on the Smart Cities PAS18x series, has taken the view of the city planner. It is at this early stage that the requirements are set for the future procurement, design, build, maintenance and operation of an asset and as such is paramount that the information requirements are specified with the future in mind. A big part of better planning is having information about the existing asset stock and its current performance to optimise that portfolio. To supplement the current Smart Cities meta standard with the right guidance regarding this, the ISO 55000 series has been mapped across, bringing in important competencies on the monitoring and performance of the asset, as well as strategic clauses related to the link between the asset and the organisational requirements.

'Smart Cities' planning is upstream of most of the lifecycle stages of an asset and, as such, this meta standard has the potential need to be the most comprehensive in scope. This is because it needs to provide sufficient information to the user, for example, the asset portfolio manager, with key information to ensure future proofing of the development in question. In addition, this meta standard needs to enable the user to elaborate a brief that clearly fulfils the needs, not only economic, but social and environmental.

At this stage, the brief should clearly identify the measures of performance, quality of service, outcomes and benefits that the development is seeking to enable, and the capability and capacity required to enable the outcomes and benefits.

In this section, we complete the Smart Cities meta standard matrix with PAS 185, published after the first proof of concept, and then compare the gaps between the Smart Cities and Asset Management matrices' competencies. We integrate asset management competencies into the original meta standard, thus creating the first DBB meta standard.

9.2.1 Updating the matrix

Since PAS 185 was only recently issued, it was not included in the initial meta standard. A matrix of the competencies of PAS 185 was created, and then mapped across the Smart Cities matrix. New clauses were created to ensure the Security Mindedness standard was explicitly included, given the criticality of this topic for our physical and digital infrastructure. In order to complete the next iteration of the meta standard we have followed the following steps:

Step 1 – Updated the original meta standard to include PAS185.

- We decomposed PAS185 into its competencies as shown in **Error! Reference source not found.**.
- We mapped the components in the PAS 185 matrix to the meta standard matrix and fused these to create an updated meta standard based on the full PAS 18x series, as shown in

Figure 28. The additions were made in purple and with a larger font for traceability. During this stage, we reviewed the dependencies with the other standards already mapped. Components with a red border are those from PAS 185. Figure 28 shows the full meta standard, with all the security relevant clauses mapped across to the relevant competencies and recommendations.

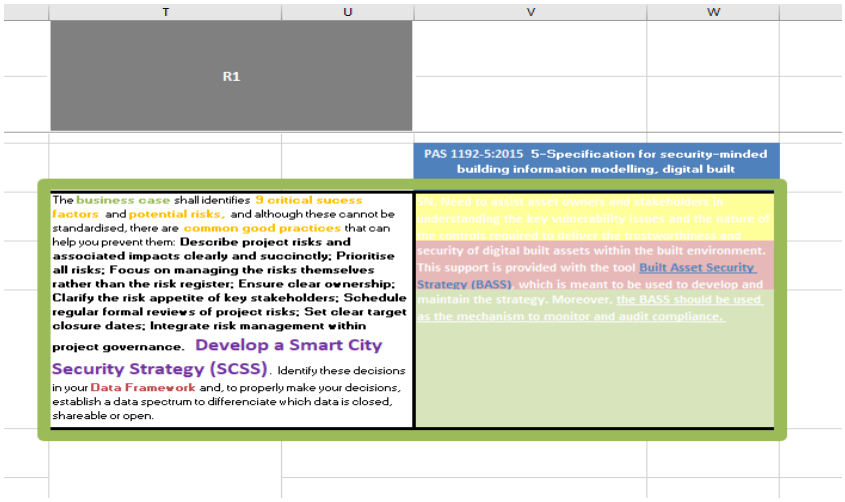


Figure 18 - example of updated meta standard clauses to include PAS185 additions

It is interesting to note that PAS 185 and PAS1192-5 have similar components and make very similar recommendations: have a SCSS (Smart City security strategy) and a BASS (built asset security strategy). They also have a similar approach – to identify critical assets, manage risk, identify roles - but are designed to be applied at different scales. This consistency is to be expected at all levels of the system although there is little evidence that this is the case in practice. Further work on the security aspects is recommended, as well as engaging a security practitioner to test the meta standard and advise on the development of this aspect.

Step 2 – integrated the asset management competencies into the original meta standard.

A gap analysis was performed between the Smart Cities and the asset management meta standards. Upon inspection, most competencies described in the Smart Cities meta standard are mirrored by the asset management meta standards. The competencies covered in both are:

- Business case should be based on the critical success factors and account for potential risks.
- City vision should be driven by commited leadership.
- Benefits' owners made responsible for the benefit realisation plan and its budget.
- Cross-sectoral distributed leadership should be citizen-centric to collaboratively design customer franchised services.
- City needs should be understood through a stakeholder engagement programme that includes customers and suppliers.
- Procure outcomes-based digitally inclusive projects that use agile delivery methods.
- Build a non-siloed resources and assets management IT architecture to enable reuse and sharing.
- Smart City's benefit-realisation strategy should consist of benefit mapping and benefit tracking.

Where a competency from ISO 55000 aligns or complements a competency in the Actionable Integrated Standard, it has been copied alongside with a red border, as shown in Figure 19.

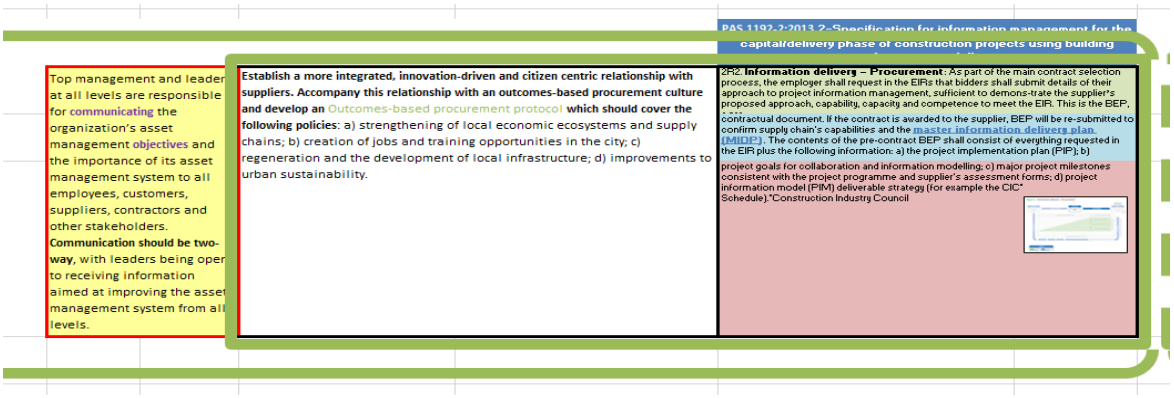


Figure 19 - Example of Asset management competency mapped across to the Smart Cities matrix

A number of competencies in the Smart Cities framework are not contemplated in the Asset management 55000 suite. However, they are essential in the planning, execution and management of assets. These topics, primarity data focused, are:

- The Smart City roadmap should leverage on physical and digital opportunities for people and businesses to interact, transact and connect.
- City's interoperability needs should be clearly identified.
- A common terminology and reference model for identity and privacy management should be created.

ISO 55001 is a strategic standard designed to guide how **plan** asset management. BS 1192 is more technical, and focuses on how the data is produced, procured and mangaged to support delivery of the asset management plan, while some topics regarding the implementation of the plan is covered in both. Figure 20 shows how 1192 is 'nested' within ISO 55000 and, in turn, how these are both linked to 9001:

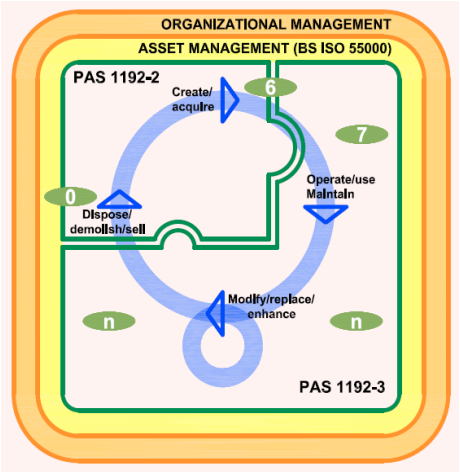


Figure 20 - Extract from PAS1192-3

While the Smart Cities framework speaks of the city scale, it is possible to address a different geospatial scale while still describing the same competencies in the meta standard. PAS 181 and 184 and ISO 55000 are strategic standards that have several closely aligned themes. These themes are generally organisational management best practice themes that could be applied universally, and also link to ISO 9001:

- Effective leadership.
- Stakeholder engagement.
- Managing risk and opportunities.
- Setting and measuring objectives.
- Setting responsibilities and accountabilities.
- Communication and changing culture.
- Coordination of resources.

There are a number of competencies that, while not initially contained in the Smart Cities framework, are essential for fulfilling the performance sought in project, and are part of ISO 55000. These focused areas have more detailed guidance within the asset management standards (ISO 55002 includes the detail) and should feature as competencies in the Smart Cities framework due to their important role in enabling feedback and performance evaluation:

- Monitoring, analysis and evaluation.
- Continual improvement.

This study did not enable us to fully explore the link between these two competencies and the IoT and technology standards in existence. The IoT standards are introduced into the meta standard in relation to each system described in the asset management plan as a result of the capability, capacity, state and quality of service required to fulfil the outcomes initially identified. While the general interoperability standards have been considered, monitoring and continuous improvement are directly linked with the particular use case, and therefore need to be introduced in that manner.

WP6 sets out an experiment where specific performance indicators are to be monitored, providing a use case that enables the development of these meta standards into a user specific tool.

9.3 Conclusions and recommendations

9.3.1 Scalability

We believe scalability of the meta standards is possible. The competencies described in the meta standards are applicable whether the asset group in question is a single building or a city asset portfolio. In addition, this approach allows for extensibility of the competencies to the meta standard, as we have seen with the addition of security components and the addition of asset management competencies. The level of detail of the standards mapped differs considerably, from the PAS 18x series, to 1192 to ISO 55000. This is a challenge that will persist in the future due to the different nature of PAS versus British Standards versus ISO. However, this challenge should not interfere with the purpose of the meta standards: to create a useful tool that provides the overall framework to understand the current and future requirements of an asset in its lifetime.

A meta standard can be reviewed but not evolved. The extensibility of the meta standard is possible - but not straightforward. The meta standard toolkit must be developed sequentially; you cannot go back once the next step commences. Gaps should be filled before finalising the gap analysis. As with the example of the smart cities meta standard, the final matrix created as part of the first proof of concept (March 2017) had to be decomposed into its unfused state in order to be able to map new standards on the matrix. This means that when a particular user view has been created and the pertinent base matrix assembled and fused, the meta standard cannot be changed. This can pose a challenge for less established methods. However, for the well-established processes, the meta standard can be transformational in how users can be guided to take a more integrative approach in the way that the built environment is planned, designed, built, operated and reported on.

Only de jure standards were used in the creation of the meta standard. However, we believe that a large proportion of the technical specifications used come from de facto standards and industry developed best practice. The meta standard sets out the framework where reference to industry best practice can be mapped. The addition of this information onto the proposed meta standard will increase the information contained in the tool, making manual development of the meta standard nearly impossible.

The content of the standards at clause level is not currently available or accessible digitally, standards are flat files. This creates limitations to the creation of a meta standard. However, new technologies, including machine learning, AI and semantic ontologies, could make standards searchable at a clause level and linked to other relevant standards. This would automate many aspects of the meta standard, enabling scalability and functionality of this tool. Moreover, the current tools used are sufficient to prove the concept to develop the meta standard framework, however, in order to develop this to the next level of content, accuracy and robustness it is necessary to explore a different interface and database.

The meta standard concept is scalable and extensible given the right tools, process of development and domain expertise. This approach elevates flat standards into a useful, informative tool and strongly supports the Level 2 Convergence thesis, to enable different stakeholder in the asset lifecycle to practice with a higher level of awareness for the requirements of information.

9.3.2 Usability

The form factor of the meta standard in its current state is not consumable to users yet. The UIL team has been able to test the content and the concept with built environment expert practitioners with positive feedback regarding the purpose of the tool. However, the current format is not viable for further expansion or consultation. This work would benefit from the input of a user experience expert that can work along the CDBB team to explore the options for developing this concept further and support the user testing as part of the proposed demonstrator in WP6.

The usability of the content is believed to be of value. However, if developed unilaterally, the meta standard can be quite subjective and likely that it would be slightly different depending on who compiled it. Therefore, a working group comprising of standards experts, subject matter experts, design experts and data/information experts should be assembled to ensure a level of consensus in the meta standard tools. The process of developing the meta standard would benefit from a user led development approach, similar to methods used for consumer product development - ultimately ensuring the expert team is responding to the needs of the user.

9.3.3 Conformance

We are not far away from a scenario of an automated planning application, where a building model is uploaded and the model automatically checked for planning approval, ensuring all the aspects of the proposed building conform to the regulation and constraints of the site.

The meta standard tool as defined in this paper is a ‘playbook’ for practitioners to do their job more effectively and be better informed. However, the information codified in the meta standard would essentially provide a framework for conformance. Linking information about the design with the meta standard would enable immediate feedback on whether the proposal meets the expectations of the brief.

As we have mentioned earlier, standards are not accessible documents. Therefore, information cannot be related to these clauses as to whether or not their requirements have been fulfilled. The Conformity Tool by BSI has produced one example of a self-conformity assessment for a specific clinical device. The use cases for self-certification in the built environment are numerous and an automating part of the conformance processes would not only reduce wasted time but help the supply chain to have confidence in their products and services for the Smart Cities and Digital Built Britain market. Products in the market already encode aspects such as technical design, for relevant standards in their functionality, however, none of them address the full lifecycle approach sought by Digital Built Britain.

Developing conformance tools linked to the meta standard for each of the categories explored - strategy, data, financial and technical - would have considerable benefits for a full lifecycle approach.

10 Appendix A

10.1 Process map

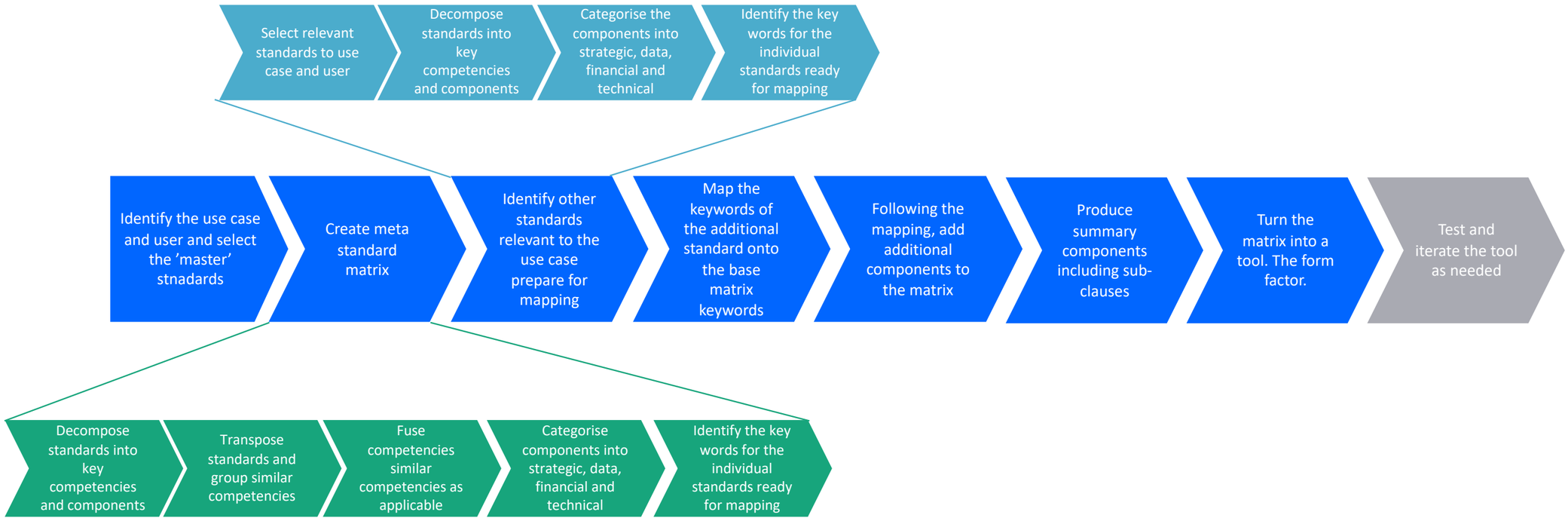


Figure 21 - Meta standard development process

10.2 Meta standard matrices

Asset management — Overview, principles and terminology		Fundamentals	Context of the organisation	Leadership	Planning (SAMP)	Support	Operation	Performance evaluation	Improvement
The need		Effective control and governance of assets by organizations is essential to realize value through managing risk and opportunity, in order to achieve the desired balance of cost, risk and performance. Asset management supports the realization of value while balancing financial, environmental and social costs, risk, quality of service and performance related to assets. This International Standard is intended to be used for managing physical assets in particular, but it can also be applied to other asset types. The fundamentals of asset management and the supporting asset management system introduced in this International Standard, when integrated into the broader governance and risk framework of an organization, can contribute tangible benefits and leverage opportunities.	When establishing or reviewing its asset management system, an organization should take into account its **internal** and **external** contexts. The external context includes the social, cultural, economic and physical environments, as well as regulatory, financial and other constraints. The internal context includes organizational culture and environment, as well as the mission, vision and values of the organization. **Stakeholder inputs,** concerns and expectations are also part of the context of the organization. Theinfluences of stakeholders are key to setting rules for consistent decision making and also contribute to the setting of organizational objectives, which in turn, influence the design and scope of its asset management system.	Top management is responsible for developing the asset management policy and asset management objectives and for aligning them with the organizational objectives. Leaders at all levels are involved in the planning, implementation and operation of the asset management system. Top management should create the vision and values that guide policy, practice and actively promote these values inside and outside the organization. Top management also defines the responsibilities, accountabilities and asset management objectives and strategies, which create the environment for the asset management system. Leaders should lend their authority to supporting the asset management system, and should ensure its alignment to other management systems within the organization through appropriate organizational design.	The principles by which the organization intends applying asset management to achieve its organizational objectives should be set out in an asset management policy (see 3.1.18).	The asset management system will require collaboration among many parts of the organization. This collaboration often involves the sharing of resources.	The organization's asset management system can enable the directing, implementation and control of its asset management activities, including those that have been outsourced.	The organization should evaluate the performance of its assets, its asset management and its asset management system. Performance measures can be direct or indirect, financial or non-financial. **Monitoring**, analysis and evaluation of this information should be a continuous process.	Continual improvement is a concept that is applicable to the assets, the asset management activities and the asset management system, including those activities or processes which are outsourced.
The strategy		This International Standard provides an overview of asset management, its principles and terminology, and the expected benefits from adopting asset management. It also provides the context for ISO 55001 and ISO 55002. Asset management is based on a set of fundamentals. **a) Value:** Assets exist to provide value to the organization and its stakeholders. **b) Alignment:** Asset management translates the organizational objectives into technical and financial decisions, plans and activities. **c) Leadership:** Leadership and workplace culture are determinants of realization of value. **d) Assurance:** Asset management gives assurance that assets will fulfil their required purpose.	The value (which can be tangible or intangible, financial or non-financial) will be determined by the **organization** and its **stakeholders**, in accordance with the organizational objectives. This includes: 1) a clear statement of how the asset management objectives align with the organizational objectives; 2) the use of a life cycle management approach to realize value from assets; 3) the establishment of decision-making processes that reflect stakeholder need and define value.	Leadership and commitment from all managerial levels is essential for successfully establishing, operating and improving asset management within the organization. This includes: 1) clearly defined roles, responsibilities and authorities; 2) ensuring that employees are aware, competent, and empowered; 3) consultation with employees and stakeholders regarding asset management.	The approach to implementing these principles should be documented in a strategic asset management plan (SAMP) (see 3.3.2).	Coordinating these resources and applying, verifying and improving their use should be objectives of the asset management system. It should also promote awareness of the asset management objectives across the whole organization	Functional policies, technical standards, plans and processes for the implementation of the asset management plans should be fed back into the design and operation of the asset management system.		The need for assurance arises from the need to effectively govern an organization. Assurance applies to assets, asset management and the asset management system. This includes: 1) developing and implementing processes that connect the required purposes and performance of the assets to the organizational objectives; 2) implementing processes for assurance of capability across all life cycle stages; 3) implementing processes for monitoring and continual improvement; 4) providing the necessary resources and competent personnel for demonstration of assurance, by undertaking asset management activities and operating the asset management system.
The recommend	R1	These influencing factors need to be considered when establishing, implementing, maintaining and continually improving asset management.— the nature and purpose of the organization; — its operating context; — its financial constraints and regulatory requirements; — the needs and expectations of the organization and its stakeholders	Asset management decisions (technical, financial and operational) collectively enable the achievement of the organizational objectives. This includes: 1) the implementation of risk-based, information-driven, planning and decision-making processes and activities that transform organizational objectives into asset management plans (see 2.5.3.4); 2) the integration of the asset management processes with the functional management processes of the organization, such as finance, human resources, information systems, logistics and operations; 3) the specification, design and implementation of a supporting asset management system	Top management and leaders at all levels are responsible for ensuring that appropriate resources are in place to support the asset management system. These resources include appropriate funding, adequate and competent human resources, and information technology support.	An organization's SAMP should be used to guide the setting of its asset management objectives, and to describe the role of the asset management system in meeting these objectives. This includes the structures, roles and responsibilities necessary to establish the asset management system and to operate it effectively. Stakeholder support, risk management and continuous improvement are important issues to be addressed in the establishment and operation of the asset management system. The SAMP can have a timeframe that extends beyond the organization's own business planning timeframe, requiring the asset management system to address the complete lifetimes of the assets.	The asset management system provides information to support the development of asset management plans and the evaluation of their effectiveness. Asset information systems can be extremely large and complex in some organizations, and there are many issues involved in collecting, verifying and consolidating asset data in order to transform it into asset information. Creating, controlling, and documenting this information is a critical function of the asset management system.	When an organization outsources some of its asset management activities, this should not remove those outsourced activities from the control of the organization's asset management system	Asset performance evaluations should be conducted on assets managed directly by the organization and on assets which are outsourced.	Opportunities for improvement can be determined directly through monitoring the performance of the asset management system, and through monitoring asset performance.Nonconformities or potential nonconformities of the asset management system can also be identified through management reviews and internal or external audits. The nonconformities require corrective action and the potential nonconformities require preventive action.
	R2	An asset management system is used by the organization to direct, coordinate and control asset management activities. It can provide improved risk control and gives assurance that the asset management objectives will be achieved on a consistent basis.key elements of an asset management system.In this context, the elements of the asset management the elements of the asset management system should be viewed as a set of tools, including policies, plans, business processes and information systems, which are integrated to give assurance that the asset management activities will be delivered NOTE The grey highlighted box designates the boundary of the asset management system. Figure B.1 — Relationship between key elements of an asset management system		Leaders should recognize and resolve conflicts between the internal culture of the organization and the performance of its asset management system.	The organization should also use its SAMP to guide its asset management system in the development of its asset management plans (i.e. in establishing what to do). The asset management plans themselves should define the activities to be undertaken on assets, and should have specific and measurable objectives (e.g. timeframes and the resources to be used). These objectives can provide the opportunity for alignment of operating plans with the organizational plan and any unit level business plans.	The asset management system should specify the competency requirements for personnel involved in asset management. The implementation, maintenance, evaluation and improvement of these competencies normally requires close cooperation with the organization's human resource management system. These two systems should be mutually supportive.	Operation of the asset management system can sometimes require planned changes to asset management processes or procedures, which can introduce new risks. Risk assessment and control in the context of managing change is an important consideration in operating an asset management system	Asset management performance should be evaluated against whether the asset management objectives have been achieved, and if not, why not. Where applicable, any opportunities that arose from having exceeded the asset management objectives should also be examined, as well as any failure to realize them. The adequacy of the decision-making processes should be examined carefully.	emergency response planning and business continuity planning for identified risks should be addressed by the asset management system. All such incidents, including unanticipated events, should be investigated and reviewed to see if any improvements are needed to the asset management system, to prevent their recurrence and to mitigate their effects
	R3	Not all asset management activities can be formalized through an asset management system. For example, aspects such as leadership, culture, motivation, behaviour, which can have a significant influence on the achievement of asset management objectives, may be managed by the organization using arrangements outside the asset management system.		Top management and leaders at all levels are responsible for communicating the organization's asset management objectives and the importance of its asset management system to all employees, customers, suppliers, contractors and other stakeholders. Communication should be two-way, with leaders being open to receiving information aimed at improving the asset management system from all levels.	Aligning the asset management objectives with the organizational objectives, as well as linking asset reports to financial reports, can improve the organization's effectiveness and efficiency, The linking of asset reports to financial reports can also improve and clarify the assessment of the financial status and long-term funding requirements of the organization			Periodic audits should be used to evaluate the performance of the asset management system; these may be complemented by self-assessments.	Improvements should be risk assessed prior to being implemented.
	R4	Using an integrated management systems approach allows an organization's asset management system to be built on elements of its other management systems, such as for quality, environment, health and safety, and risk management. Building on existing systems can reduce the effort and expense involved in creating and maintaining an asset management system. It can also improve integration across different disciplines and improve cross-functional coordination. Asset management, because it touches so many parts of the organization, is a natural candidate for an integrated systems approach.						The results of performance evaluations should be used as inputs into management reviews	

Annex B

Yellow: ***strategy and vision***
Magenta: ***data and information***
Green: ***investment and expenditure***
Blue: ***technical and technological***

Figure 22 - ISO 55000 decomposition

Asset management — Management systems — Requirements		Fundamentals	Context of the organisation	Leadership	Planning	Support	Operation	Performance evaluation	Improvement	Intergrated Management System
The need		This International Standard specifies requirements for an asset management system within the context of the organization.								
The strategy										
The recommend	R1	The organization shall establish, implement, maintain and continually improve an asset management system, including the processes needed and their interactions, in accordance with the requirements of this International Standard.	**Understanding the organization and its context** The organization shall determine external and internal issues that are relevant to its purpose and that affect its ability to achieve the intended outcome(s) of its asset management system. Asset management objectives, included in the strategic asset management plan (SAMP), shall be aligned to, and consistent with, the organizational objectives.	**5.1 Leadership and commitment** Top management shall demonstrate leadership and commitment with respect to the asset management system by: — ensuring that the asset management policy, the SAMP and asset management objectives are established and are compatible with the organizational objectives; — ensuring the integration of the asset management system requirements into the organization's business processes; — ensuring that the resources for the asset management system are available; — communicating the importance of effective asset management and of conforming to the asset management system requirements; — ensuring that the asset management system achieves its intended outcome(s); — directing and supporting persons to contribute to the effectiveness of the asset management system; — promoting cross-functional collaboration within the organization; — promoting continual improvement; — supporting other relevant management roles to demonstrate their leadership as it applies to their areas of responsibility; — ensuring that the approach used for managing risk in asset management is aligned with the organization's approach for managing risk.	**6.1 Actions to address risks and opportunities for the asset management system** When planning for the asset management system, the organization shall consider the issues referred to in 4.1 and the requirements referred to in 4.2 and determine the risks and opportunities that need to be addressed to: — give assurance that the asset management system can achieve its intended outcome(s); — prevent, or reduce undesired effects; — achieve continual improvement.	**Resources** The organization shall determine and provide the resources needed for the establishment, implementation, maintenance and continual improvement of the asset management system. The organization shall provide the resources required for meeting the asset management objectives and for implementing the activities specified in the asset management plan(s).	**8.1 Operational planning and control** The organization shall plan, implement and control the processes needed to meet requirements, and to implement the actions determined in 6.1, the asset management plan(s) determined in 6.2, and the corresponding and preventive actions determined in 10.1 and 10.2 by: — establishing criteria for the required processes; — implementing the control of the processes in accordance with the criteria; — keeping documented information to the extent necessary to have confidence and evidence that the processes have been carried out as planned; — treating and monitoring risks using the approach described in 6.2.2.	**9.1 Monitoring, measurement, analysis and evaluation** The organization shall determine: a) what needs to be monitored and measured; b) the methods for monitoring, measurement, analysis and evaluation, as applicable, to ensure valid results; c) when the monitoring and measuring shall be performed; d) when the results from monitoring and measurement shall be analysed and evaluated. The organization shall evaluate and report on — the asset performance; — the asset management performance, including financial and non-financial performance; — the effectiveness of the asset management system. The organization shall evaluate and report on the effectiveness of the processes for managing risks and opportunities. The organization shall retain appropriate documented information as evidence of the results of monitoring, measurement, analysis and evaluation. The organization shall ensure that its monitoring and measurement enables it to meet the requirements of 4.2.	**10.1 Nonconformity and corrective action** When a nonconformity or incident occurs in its assets, asset management or asset management system the organization shall: a) react to the nonconformity or incident, and, as applicable: — take action to control and correct it; — deal with the consequences; b) evaluate the need for action to eliminate the causes of the nonconformity or incident, in order that it does not occur or recur elsewhere, by: — reviewing the nonconformity or incident; — determining the causes of nonconformity or incident; — determining if similar nonconformities exist, or could potentially occur; c) implement any action needed; d) review the effectiveness of any corrective action taken; and e) make changes (see 8.2) to the asset management system, if necessary. Corrective actions shall be appropriate to the effects of the nonconformities or incident encountered. The organization shall retain documented information as evidence of: — the nature of the nonconformities or incident and any subsequent actions taken; — the results of any corrective action.	
	R2	The organization shall develop a SAMP which includes documentation of the role of the asset management system in supporting achievement of the asset management objectives.	**Understanding the needs and expectations of stakeholders** The organization shall determine: — the stakeholders that are relevant to the asset management system; — the requirements and expectations of these stakeholders with respect to asset management; — the criteria for asset management decision making; — the stakeholder requirements for recording financial and non-financial information relevant to asset management, and for reporting on it both internally and externally.	**5.2 Policy** Top management shall establish an asset management policy that: a) is appropriate to the purpose of the organization; b) provides a framework for setting asset management objectives; c) includes a commitment to satisfy applicable requirements; d) includes a commitment to continual improvement of the asset management system. The asset management policy shall: — be consistent with the organizational plan; — be consistent with other relevant organizational policies; — be appropriate to the nature and scale of the organization's assets and operations; — be available as documented information; — be communicated within the organization; — be available to stakeholders, as appropriate; — be implemented and be periodically reviewed and, if required, updated.	**The organization shall plan:** a) actions to address these risks and opportunities, taking into account how these risks and opportunities can change with time; b) how to: — integrate and implement the actions into its asset management system processes; — evaluate the effectiveness of these actions.	**Competence** The organization shall: — determine the necessary competence of person(s) doing work under its control that affects its asset performance, asset management performance and asset management system performance; — ensure that these persons are competent on the basis of appropriate education, training, or experience; — where applicable, take actions to acquire the necessary competence, and evaluate the effectiveness of the actions taken; — retain appropriate documented information as evidence of competence; — periodically review current and future competency needs and requirements	**8.2 Management of change** Risks associated with any planned change, permanent or temporary that can have an impact on achieving the asset management objectives, shall be assessed before the change is implemented. The organization shall ensure that such risks are managed in accordance with 6.1 and 6.2.2. The organization shall control planned changes and review the unintended consequences of changes, taking action to mitigate any adverse effects, as necessary.	**9.2 Internal audit** 9.2.1 The organization shall conduct internal audits at planned intervals to provide information to assist in the determination on whether the asset management system: a) conforms to: — the organization's own requirements for its asset management system; — the requirements of this International Standard; b) is effectively implemented and maintained. 9.2.2 The organization shall: a) plan, establish, implement and maintain an audit programme(s), including the frequency, methods, responsibilities, planning requirements and reporting. The audit programme(s) shall take into consideration the importance of the processes concerned and the results of previous audits; b) define the audit criteria and scope for each audit; c) select auditors and conduct audits to ensure objectivity and the impartiality of the audit process; d) ensure that the results of the audits are reported to relevant management; and e) retain documented information as evidence of the results of the implementation of the audit programme and the audit results.	**10.2 Preventive action** The organization shall establish processes to proactively identify potential failures in asset performance and evaluate the need for preventive action. When a potential failure is identified the organization shall apply the requirements of 10.1.	
	R3		**Determining the scope of the asset management system** The organization shall determine the boundaries and applicability of the asset management system to establish its scope. The scope shall be aligned with the SAMP and the asset management policy. When determining this scope, the organization shall consider: — the external and internal issues referred to in 4.1; — the requirements referred to in 4.2; — the interaction with other management systems, if used. The organization shall define the asset portfolio covered by the scope of the asset management system. The scope shall be available as documented information	**5.3 Organizational roles, responsibilities and authorities** Top management shall ensure that the responsibilities and authorities for relevant roles are assigned and communicated within the organization. Top management shall assign the responsibility and authority for: a) establishing and updating the SAMP, including asset management objectives; b) ensuring that the asset management system supports delivery of the SAMP; c) ensuring that the asset management system conforms to the requirements of this International Standard; d) ensuring the suitability, adequacy and effectiveness of the asset management system; e) establishing and updating the asset management plan(s) (see 6.2.2); f) reporting on the performance of the asset management system to top management.	6.2 Asset management objectives and planning to achieve them **6.2.1 Asset management objectives** The organization shall establish asset management objectives at relevant functions and levels. When establishing its asset management objectives, the organization shall consider the requirements of relevant stakeholders and of other financial, technical, legal, regulatory and organizational requirements in the asset management planning process. The asset management objectives shall: — be consistent and aligned with the organizational objectives; — be consistent with the asset management policy; — be established and updated using asset management decision-making criteria (see 4.2); — be established and updated as part of the SAMP; — be measurable (if practicable); — take into account applicable requirements; — be monitored; — be communicated to relevant stakeholders; — be reviewed and updated as appropriate. The organization shall retain documented information on the asset management objectives.	**7.3 Awareness** Persons doing work under the organization's control, who can have an impact on the achievement of the asset management objectives, shall be aware of: — the asset management policy; — their contribution to the effectiveness of the asset management system, including the benefits of improved asset management performance; — their work activities, the associated risks and opportunities and how they relate to each other; — the implications of not conforming to the asset management system requirements.	**8.3 Outsourcing** When the organization outsources any activities that can have an impact on the achievement of its asset management objectives, it shall assess the associated risks. The organization shall ensure that outsourced processes and activities are controlled. The organization shall determine and document how these activities will be controlled and integrated into the organization's asset management system. The organization shall determine: a) the processes and activities that are to be outsourced (including the scope and boundaries of the outsourced processes and activities and their interfaces with the organization's own processes and activities); b) the responsibilities and authorities within the organization for managing the outsourced processes and activities; c) the processes and scope for the sharing of knowledge and information between the organization and its contracted service provider(s). When outsourcing any activities, the organization shall ensure that: — the outsourced resources meet the requirements of 7.2, 7.3 and 7.6; — the performance of the outsourced activities is monitored in accordance with 9.1. 9 Performance	**9.3 Management review** Top management shall review the organization's asset management system, at planned intervals, to ensure its continuing suitability, adequacy and effectiveness. The management review shall include consideration of: a) the status of actions from previous management reviews; b) changes in external and internal issues that are relevant to the asset management system;c) information on the asset management performance, including trends in: — nonconformities and corrective actions; — monitoring and measurement results; — audit results; d) asset management activity; e) opportunities for continual improvement; f) changes in the profile of risks and opportunities. The outputs of the management review shall include decisions related to continual improvement opportunities and any need for changes (see 8.2) to the asset management system. The organization shall retain documented information as evidence of the results of management reviews.	**10.3 Continual improvement** The organization shall continually improve the suitability, adequacy and effectiveness of its asset management and the asset management system	
	R4				**6.2.2 Planning to achieve asset management objectives** The organization shall integrate the planning to achieve asset management objectives with other organizational planning activities, including financial, human resources and other support functions. The organization shall establish, document and maintain asset management plan(s) to achieve the asset management objectives. These asset management plan(s) shall be aligned with the asset management policy and the SAMP. The organization shall ensure that the asset management plan(s) take(s) into account relevant requirements coming from outside the asset management system. When planning how to achieve its asset management objectives, the organization shall determine and document: a) the method and criteria for decision making and prioritizing of the activities and resources to achieve its asset management plan(s) and asset management objectives; b) the processes and methods to be employed in managing its assets over their life cycles;c) what will be done; d) what resources will be required; e) who will be responsible; f) when it will be completed; g) how the results will be evaluated; h) the appropriate time horizon(s) for the asset management plan(s); i) the financial and non-financial implications of the asset management plan(s); j) the review period for the asset management plan(s) (see 9.1); k) actions to address risks and opportunities associated with managing the assets, taking into account	**7.4 Communication** The organization shall determine the need for internal and external communications relevant to assets, asset management and the asset management system including: — on what it will communicate; — when to communicate; — with whom to communicate; — how to communicate.				
	R5					**7.5 Information requirements** The organization shall determine its information requirements to support its assets, asset management, asset management system and the achievement of its organizational objectives. In doing this: a) the organization shall include consideration of: — the significance of the identified risks; — the roles and responsibilities for asset management; — the asset management processes, procedures and activities; — the exchange of information with its stakeholders, including service providers; — the impact of quality, availability and management of information on organizational decision making; b) the organization shall determine: — the attribute requirements of identified information; — the quality requirements of identified information; — how and when information is to be collected, analysed and evaluated; c) the organization shall specify, implement and maintain processes for managing its information; d) the organization shall determine the requirements for alignment of financial and non-financial terminology relevant to asset management throughout the organization; e) the organization shall ensure that there is consistency and traceability between the financial and technical data and other relevant non-financial data, to the extent required to meet its legal and regulatory requirements while considering its stakeholders' requirements and organizational objectives.			
	R6					**Documented Information 7.6.1 General** The organization's asset management system shall include: — documented information as required by this International Standard; — documented information for applicable legal and regulatory requirements; — documented information determined by the organization as being necessary for the effectiveness of the asset management system, as specified in 7.5.				
	R7					**7.6.2 Creating and updating** When creating and updating documented information the organization shall ensure appropriate: — identification and description (e.g. a title, date, author, or reference number); — format (e.g. language, software version, graphics) and media (e.g. paper, electronic); — review and approval for suitability and adequacy				
	R8					7.6.3 Control of documented information Documented information required by the asset management system and by this International Standard shall be controlled to ensure: a) it is available and suitable for use, where and when it is needed; b) it is adequately protected (e.g. from loss of confidentiality, improper use, or loss of integrity). For the control of documented information, the organization shall address the following activities, as applicable: — distribution, access, retrieval and use; — storage and preservation, including preservation of legibility; — control of changes (e.g. version control); — retention and disposition. Documented information of external origin determined by the organization to be necessary for the planning				

Yellow: **strategy and vision**
Magenta: **data and information**
Green: **investment and expenditure**
Blue: **technical and technological**

Figure 23 - ISO 55001 decomposition

Asset management — Overview, principles and terminology		Fundamentals	Context of the organisation	Leadership	Planning (SAMP)	Support	Operation	Performance evaluation	Improvement
The need		Effective control and governance of assets by organizations is essential to **realize value** through **managing risk and opportunity**, in order to achieve the desired balance of cost, risk and performance. Asset management supports the realization of **value** while balancing financial, environmental and social costs, risk, quality of service and performance related to assets (assets don't have to be physical).	organizations should take into account its **internal and external contexts**. The external context includes the social, cultural, economic and physical environments, as well as regulatory, financial and other constraints. The internal context includes organizational culture and environment, as well as the mission, vision and values of the organization. **Stakeholder inputs**, concerns and expectations are also part of the context of the organization. The influences of stakeholders are key to setting rules for consistent decision making and also contribute to the setting of **organizational objectives**, which in turn, influence the design and scope of its asset management system.	Top management is responsible for developing the asset management **policy** and asset management **objectives** and for aligning them with the **organizational objectives**. Leaders at all levels are involved in the planning, implementation and operation of the asset management system. Top management should create the vision and values that guide policy, practice and actively promote these values inside and outside the organization. Top management also defines the **responsibilities**, **accountabilities** and asset management objectives and strategies, which create the environment for the asset management system. Leaders should lend their authority to supporting the asset management system, and should ensure its alignment to other management systems within the organization through appropriate organizational design.	The principles by which the organization intends applying asset management to achieve its **organizational objectives** should be set out in an **asset management policy** (see 3.1.18).	The asset management system will require **collaboration** among many parts of the organization. This collaboration often involves the sharing of **resources**. **Coordinating these resources** and applying, verifying and improving their use should be **objectives** of the asset management system. It should also **promote awareness of the asset management objectives** across the whole organization	The organization's **asset management system** can enable the directing, implementation and **control of its asset management activities**, including those that have been **outsourced.**	The organization should **evaluate the performance of its assets, its asset management and its asset management system**. Performance measures can be direct or indirect, financial or non-financial. **Monitoring, analysis and evaluation** of this information should be a continuous process.	The need for assurance arises from the need to effectively govern an organization. **Assurance** applies to assets, asset management and the asset management system.
The strategy		Asset management is based on a set of fundamentals. Assets exist to provide **value** to the organization and its stakeholders. Asset management translates the **organizational objectives** into technical and financial **decisions, plans and activities**. and provides assurance that assets will fulfil their required purpose.Leadership and workplace culture are determinants of realization of value.	The value of an asset (which can be tangible or intangible, financial or non-financial) will be determined by the **organization** and its **stakeholders**, in accordance with the **organizational objectives**. The organisation should develop a statement of how the **asset management objectives align with the organizational objectives**; define a **life cycle management approach** to realize value from assets and establish a **decision-making processes** that reflect stakeholder need and define value.	Leadership and commitment from all managerial levels is essential for successfully establishing, operating and improving asset management within the organization. **Roles, responsibilities and authorities** should be clearly defined.Employees should be **aware, competent, and empowered**. Employees and stakeholders should be **consulted with** regarding asset management.	The approach to implementing these principles should be documented in a **strategic asset management plan (SAMP)** (see 3.3.2).	The **asset management system** provides information to support the development of **asset management plans** and the evaluation of their effectiveness. Asset information systems can be extremely large and complex in some organizations, and there are many issues involved in collecting, **verifying and consolidating asset data** in order to transform it into asset information. Creating, controlling, and documenting this information is a critical function of the asset management system.	Functional **policies, technical standards, plans and processes** for the implementation of the asset management plans should be fed back into the design and operation of the asset management system.	**Asset performance evaluations** should be conducted on assets managed directly by the organization and on assets which are outsourced.	. Assurance includes 1) developing and implementing processes that connect the required purposes and performance of the assets to the **organizational objectives;** 2) implementing processes for **assurance** of capability across all **life cycle stages**; 3) implementing processes for **monitoring** and **continual improvement**; 4) providing the necessary **resources** and **competent personnel** for demonstration of assurance, by undertaking asset management activities and operating the asset management system.
The recommend	R1	An **asset management system** is a **set of tools** used by the organization to direct, coordinate and control asset management activities; through **policies, plans, business processes and information systems** it can provide improved risk control and gives assurance that the asset management objectives will be achieved on a consistent basis.		Top management and leaders at all levels are responsible for ensuring that appropriate **resources** are in place to support the asset management system. These **resources** include appropriate funding, adequate and competent human **resources,** and information technology support.	An organization's **SAMP** should be used to guide the **setting of its asset management objectives**, and to describe the **role** of the asset management system in meeting these **objectives**. This includes the structures, roles and responsibilities necessary to establish the asset management system and to operate it effectively. **Stakeholder support, risk management and continuous improvement** are important issues to be addressed in the establishment and operation of the asset management system. The **SAMP** can have a **timeframe** that extends beyond the organization's own business planning timeframe, requiring the asset management system to address the **complete lifetimes** of the assets.	**The asset management system** should specify the **competency requirements for personnel** involved in asset management. The implementation, maintenance, evaluation and improvement of these competencies normally requires close **cooperation with the organization's human resource management system**. These two systems should be mutually supportive.	When an organization **outsources** some of its asset management activities, this should not remove those **outsourced activities** from the **control** of the organization's asset management system	**Asset management performance should be evaluated** against whether the asset management **objectives have been achieved, and if not, why not**. Where applicable, any opportunities that arose from having exceeded the asset management objectives should also be examined, as well as any failure to realize them. The adequacy of the decision-making processes should be examined carefully.	**Opportunities for improvemen**t can be determined directly through **monitoring the performance** of the asset management system, and through **monitoring asset performance**.Nonconformities or potential nonconformities of the asset management system can also be identified through management reviews and internal or external **audits**. The nonconformities require corrective action and the potential nonconformities require preventive action.
	R2	Not all asset management activities can be formalized through an asset management system. For example, aspects such as **leadership, culture, motivation, behaviour**, which can have a significant influence on the achievement of asset management objectives, may be managed by the organization using arrangements outside the asset management system.		Leaders should recognize and resolve conflicts between the **internal culture** of the organization and the performance of its asset management system.	The organization should also use its **SAMP** to guide its asset management system in the development of its **asset management plans** (i.e. in establishing what to do). The **asset management plans** themselves should define the activities to be undertaken on assets, and should have **specific** and **measurable objectives** (e.g. timeframes and the resources to be used). These objectives can provide the opportunity for alignment of operating plans with the organizational plan and any unit level business plans.		Operation of the asset management system can sometimes require **planned changes** to asset management processes or procedures, which can introduce new **risks**. **Risk assessment and control in the context of managing change** is an important consideration in operating an asset management system	**Periodic audits** should be used to evaluate the performance of the asset management system; these may be complemented by self-assessments.	**emergency response planning and business continuity planning** for identified **risks** should be addressed by the asset management system. All such incidents, including unanticipated events, should be investigated and reviewed to see if any improvements are needed to the asset management system, to prevent their recurrence and to mitigate their effects
	R3	Using an **integrated management systems** approach allows an organization's asset management system to be built on elements of its other management systems, such as for quality, environment, health and safety, and risk management. Building on existing systems can reduce the effort and expense involved in creating and maintaining an asset management system. It can also improve integration across different disciplines and improve cross-functional coordination. Asset management, because it touches so many parts of the organization, is a natural candidate for an integrated systems approach.		Top management and leaders at all levels are responsible for **communicating** the organization's asset management **objectives** and the importance of its asset management system to all employees, customers, suppliers, contractors and other stakeholders. **Communication should be two-way**, with leaders being open to receiving information aimed at improving the asset management system from all levels.	**Aligning the asset management objectives with the organizational objectives**, as well as **linking asset reports to financial reports**, can improve the organization's effectiveness and efficiency, **The linking of asset reports to financial reports can also improve and clarify the assessment of the financial status and long-term funding requirements of the organization**			**The results of performance evaluations should be used as inputs into management reviews**	**Improvements should be risk assessed** prior to being implemented.
	R4								

Yellow: ***strategy and vision***
Magenta: ***data and information***
Green: ***investment and expenditure***
Blue: ***technical and technological***

Figure 24 - Asset management meta standard matrix showing key competencies

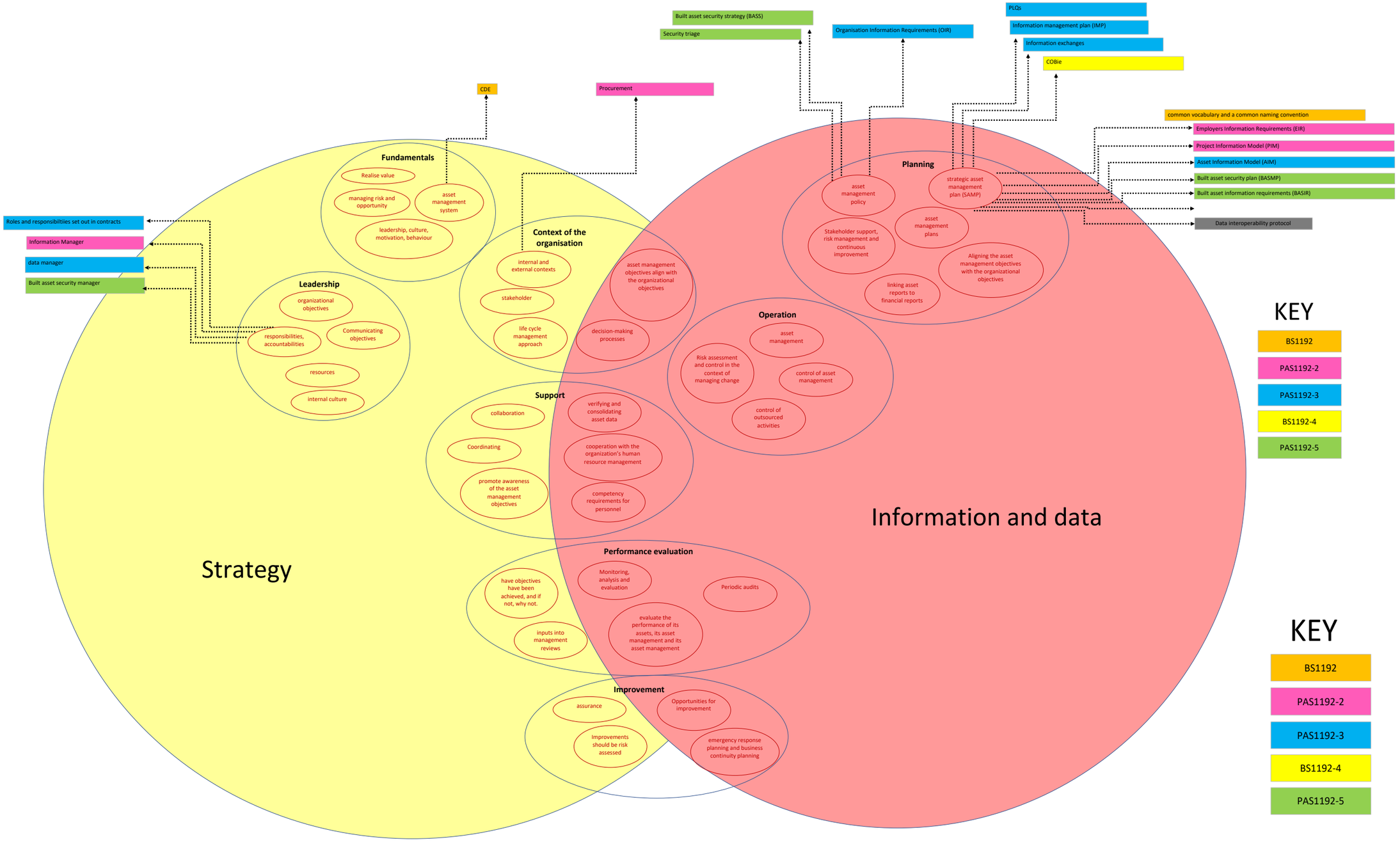


*Figure **Error! Unknown switch argument.**: keyword mapping between 55000 and BS 1192 series*

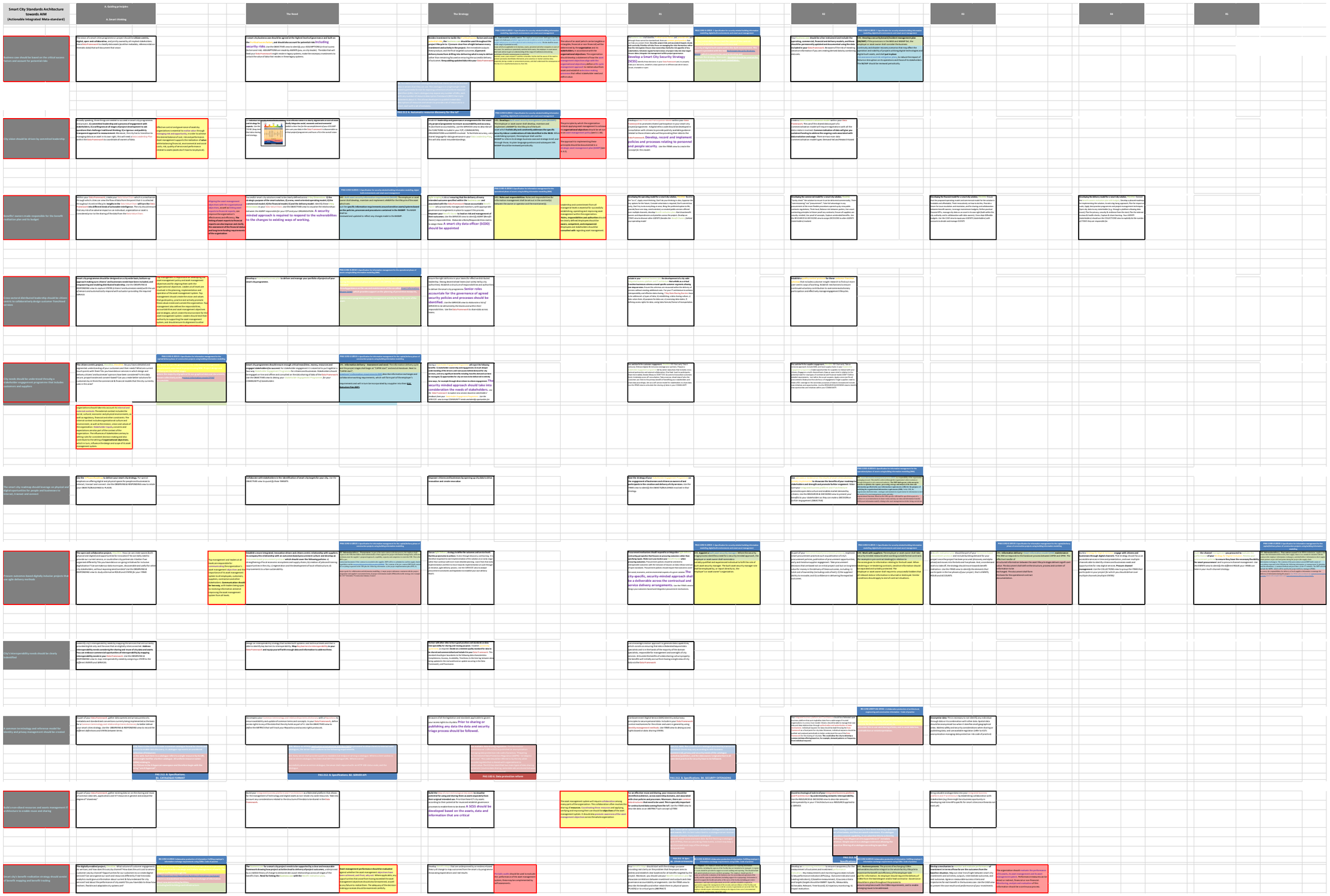
Asset management — Overview, principles and terminology	The need	The strategy	The recommend		
			R1	R2	R3
Fundamentals	Effective control and governance of assets by organizations is essential to **realize value** through **managing risk and opportunity**, in order to achieve the desired balance of cost, risk and performance. Asset management supports the realization of **value** while balancing financial, environmental and social costs, risk, quality of service and performance related to assets (assets don't have to be physical).	Asset management is based on a set of fundamentals. Assets exist to provide **value** to the organization and its stakeholders. Asset management translates the **organizational objectives** into technical and financial **decisions, plans and activities**. and provides assurance that assets will fulfil their required purpose.Leadership and workplace culture are determinants of realization of value.	An **asset management system** is a **set of tools** used by the organization to direct, coordinate and control asset management activities; through **policies, plans, business processes and information systems** it can provide improved risk control and gives assurance that the asset management objectives will be achieved on a consistent basis. **IR2. Common Data Environment (CDE)** and Asset Information Model (AIM): The organization shall implement processes to provide BS-1192's CDE in order to maintain integrity and control of the data and information throughout the supply chain. An existing AIM shall be identified, or a new AIM shall be created, at the inception of a trigger event	Not all asset management activities can be formalized through an asset management system. For example, aspects such as **leadership, culture, motivation, behaviour**, which can have a significant influence on the achievement of asset management objectives, may be managed by the organization using arrangements outside the asset management system.	Using an **integrated management systems** approach allows an organization's asset management system to be built on elements of its other management systems, such as for quality, environment, health and safety, and risk management. Building on existing systems can reduce the effort and expense involved in creating and maintaining an asset management system. It can also improve integration across different disciplines and improve cross-functional coordination. Asset management, because it touches so many parts of the organization, is a natural candidate for an integrated systems approach.
Context of the organisation	organizations should take into account its **internal and external contexts**. The external context includes the social, cultural, economic and physical environments, as well as regulatory, financial and other constraints. The internal context includes organizational culture and environment, as well as the mission, vision and values of the organization. **Stakeholder inputs**, concerns and expectations are also part of the context of the organization. The influences of stakeholders are key to setting rules for consistent decision making and also contribute to the setting of **organizational objectives**, which in turn, influence the design and scope of its asset management system.	The value of an asset (which can be tangible or intangible, financial or non-financial) will be determined by the **organization** and its **stakeholders**, in accordance with the **organizational objectives**. The organization should develop a statement of how the **asset management objectives align with the organizational objectives**; define a **life cycle management approach** to realize value from assets and establish a **decision-making processes** that reflect stakeholder need and define value.			
	Procurement. Suppliers should be assessed using a capability assessment. As part of the main contract selection process, the employer shall request in the EIRs that bidders shall submit details of their approach to project information management, suffi cient to demonstrate the supplier's proposed approach, capability, capacity and competence to meet the EIR				
Leadership	Top management is responsible for developing the asset management **policy** and asset management **objectives** and for aligning them with the **organizational objectives**. Leaders at all levels are involved in the planning, implementation and operation of the asset management system. Top management should create the vision and values that guide policy, practice and actively promote these values inside and outside the organization. Top management also defines the **responsibilities, accountabilities** and asset management objectives and strategies, which create the environment for the asset management system. Leaders should lend their authority to supporting the asset management system, and should ensure its alignment to other management systems within the organization through appropriate organizational design.	Leadership and commitment from all managerial levels is essential for successfully establishing, operating and improving asset management within the organization. **Roles, responsibilities and authorities** should be clearly defined.Employees should be **aware, competent, and empowered**. Employees and stakeholders should be **consulted with** regarding asset management.	Top management and leaders at all levels are responsible for ensuring that appropriate **resources** are in place to support the asset management system. These **resources** include appropriate funding, adequate and competent human **resources,** and information technology support.	Leaders should recognize and resolve conflicts between the **internal culture** of the organization and the performance of its asset management system.	Top management and leaders at all levels are responsible for **communicating** the organization's asset management **objectives** and the importance of its asset management system to all employees, customers, suppliers, contractors and other stakeholders. **Communication should be two-way**, with leaders being open to receiving information aimed at improving the asset management system from all levels.
	Establish the **OIR** based on the asset management activities identified in the policy, strategy and plan, which may be developed through BS ISO 55000 – see 4.4.	An **EIR** and **AIR** should be developed from the OIR. Asset Information Requirements (AIR) are data and information requirements of the organization in relation to the asset(s) it is responsible for. Where assets are subject to a **capital/delivery phase** this means there is a link with those information management processes defined in PAS 1192-2. **PAS1192-2** describes the requirements of an EIR. BS 1192-4 defines the UK usage of COBie, an internationally agreed information exchange schema for exchanging facility information between the employer and the supply chain.	6.1 Where the security triage process identifies a need for a security-minded approach, the employer or asset owner shall nominate a suitably qualified and experienced individual to fulfil the role of **built asset security manager**.	In accordance with ISO/TS 8000-150, **a data manager** should have the responsibility for accepting information into the shared area of the CDE and for authorizing it for the published area.	**Roles and responsibilities for information management as defined in this PAS** shall be set out in the **contract(s)** between the owner or operator and the maintainer(s).	PAS1192-2 Information Manager. Under the BIM Protocol, a client is obligated to appoint an information manager at all project stages.
Planning (SAMP)	The principles by which the organization intends applying asset management to achieve its **organizational objectives** should be set out in an **asset management policy** (see 3.1.18).	The approach to implementing these principles in the policy should be documented in a **strategic asset management plan (SAMP)** (see 3.3.2).	An organization's **SAMP** should be used to guide the **setting of its asset management objectives**, and to describe the **role** of the asset management system in meeting these **objectives**. This includes the structures, roles and responsibilities necessary to establish the asset management system and to operate it **effectively**. **Stakeholder support, risk management and continuous improvement** are important issues to be addressed in the establishment and operation of the asset management system.The **SAMP** can have a **timeframe** that extends beyond the organization's own business planning timeframe, requiring the asset management system to address the **complete lifetimes** of the assets.	The organization should also use its **SAMP** to guide its asset management system in the development of its **asset management plans** (i.e. in establishing what to do). The **asset management plans** themselves should define the activities to be undertaken on assets, and should have **specific** and **measurable objectives** (e.g. timeframes and the resources to be used). These objectives can provide the opportunity for alignment of operating plans with the organizational plan and any unit level business plans.	**Aligning the asset management objectives with the organizational objectives**, as well as **linking asset reports to financial reports**, can improve the organization's effectiveness and efficiency. **The linking of asset reports to financial reports can also improve and clarify the assessment of the financial status and long-term funding requirements of the organization**
	7.1.1 The employer or asset owner shall develop and maintain a **BASS** which shall include: a) the security requirements determined by the security triage process; b) the built asset risk management strategy (see 7.2) comprising: i) the record of the risk assessment; ii) the record of the risk mitigation process; iii) the measures to be implemented; iv) a summary of the residual risks; c) a list of those to be informed about the residual risks; and d) the mechanisms for reviewing and updating the BASS (see 7.3).	SR2. Understand the overall security threat to a built asset: The employer or asset owner shall apply a security triage process to identify the need for a security-minded approach	The employer or asset owner shall develop, maintain and implement a **BASMP** for the lifecycle of the built asset which addresses the specific security risks or combinations of risks identified in the BASS in a consistent and holistic manner	10.1 The employer or asset owner shall develop, maintain and implement a **BASIR** for the lifecycle of the asset which sets out the specific information requirements around sensitive assets/systems based on the policies, processes and procedures contained in the BASMP. 10.2 The BASIR shall inform the asset information requirements (AIR) and, in a project, the EIR (see Figure 2).	The **IMP** (Information Management plan) shall cover the operational lifecycle of the asset including, but not limited to, handover from design and construction, day-to-day operation of the asset, planned and reactive maintenance, minor works, major works, decommissioning, and dismantling or demolition.	Data interoperability should be considered. PAS 212 specifies a protocol whereby any compliant software client can automatically discover data that is stored within any compliant software server, without either the client or server having to be written to have been explicitly compatible with each other. PAS 212 can be used by commissioners of software projects, who, by recommending compliance to this specification, can promote open interoperability between the project parts, and thus avoid vendor lock-in.	PAS 1192-2 focuses specifi cally on project delivery, where the majority of graphical data, non-graphical data and documents, known collectively as the project information model (PIM), are accumulated fromdesign and construction activities.
		provision of a clear definition of the employer's information requirements (EIR) and key decision points (to form part of the contract possibly through adoption of the PCC BIM Protocol)	9.1.2 The employer or asset owner shall create and maintain a **SII/IMP** tailored to the enterprise, its function, and the assets that may be affected, to be followed both by its own personnel and, where appropriate, by its supply chain.	4.6.1 Creation of the **AIM** The AIM shall be created in accordance with the organization's requirements. This shall be achieved through a variety of management activities, including some or all of the following: a) transfer of information and data from existing organizational systems into the AIM; b) recognizing or relabelling an existing data and information store as part of the AIM; c) collection of new or updated information and data from surveys of the physical asset; d) exchange of information and data with project information model(s) generated as a result of BIM Level 2 capital/delivery projects as specified by PAS 1192-2.	4R4. Implementation: The implementation of **COBie** and the delivery of the EIR should be specific and appropriate to the facility and should be led by the employer. Implementation should be through the use of robust applications, shared structured data and repeatable processes. Existing Facilities and the context of new Facilities should be documented	Information requirements set out in the EIRs shall only provide enough information to answer the "Plain Language Questions" **(PLQs)** required at a particular stage, at an appropriate level of detail.
Support	The asset management system will require **collaboration** among many parts of the organization. This collaboration often involves the sharing of **resources**. **Coordinating these resources** and applying, verifying and improving their use should be **objectives** of the asset management system. It should also **promote awareness of the asset management objectives** across the whole organization		The **asset management system** provides information to support the development of **asset management plans** and the evaluation of their effectiveness. Asset information systems can be extremely large and complex in some organizations, and there are many issues involved in collecting, **verifying and consolidating asset data** in order to transform it into asset information. Creating, controlling, and documenting this information is a critical function of the asset management system.		**The asset management system** should specify the **competency requirements for personnel** involved in asset management. The implementation, maintenance, evaluation and improvement of these competencies normally requires close **cooperation with the organization's human resource management system**. These two systems should be mutually supportive.	
Operation	The organization's **asset management system** can enable the directing, implementation and **control of its asset management activities**, including those that have been **outsourced**.		Functional **policies, technical standards, plans and processes** for the implementation of the asset management plans should be fed back into the design and operation of the asset management system.		When an organization **outsources** some of its asset management activities, this should not remove those outsourced activities from the **control** of the organization's asset management system	Operation of the asset management system can sometimes require **planned changes** to asset management processes or procedures, which can introduce new **risks. Risk assessment** and control in the context of managing change is an important
Performance evaluation	The organization should **evaluate the performance of its assets, its asset management and its asset management system**. Performance measures can be direct or indirect, financial or non-financial. **Monitoring, analysis and evaluation** of this information should be a continuous process.		**Asset performance evaluations** should be conducted on assets managed directly by the organization and on assets which are outsourced.		**Asset management performance should be evaluated** against whether the asset management objectives have been achieved, and if not, why not. Where applicable, any opportunities that arose from having exceeded the asset management objectives should also be examined, as well as any failure to realize them. The adequacy of the decision-making processes should be examined carefully.	**Periodic audits** should be used to evaluate the performance of the asset management system; these may be complemented by self-assessments.	**The results of performance evaluations should be used as inputs into management reviews**
Improvement	The need for assurance arises from the need to effectively govern an organization. **Assurance** applies to assets, asset management and the asset management system.	. Assurance includes 1) developing and implementing processes that connect the required purposes and performance of the assets to the **organizational objectives;** 2) implementing processes for **assurance** of capability across all **life cycle stages**; 3) implementing processes for **monitoring** and **continual improvement**; 4) providing the necessary **resources** and **competent personnel** for demonstration of assurance, by undertaking asset management activities and operating the asset management system.			Opportunities for **improvement** can be determined directly through **monitoring the performance** of the asset management system, and through **monitoring asset performance**.Nonconformities or potential nonconformities of the asset management system can also be identified through management reviews and internal or external **audits**. The nonconformities require corrective action and the potential nonconformities require preventive action.	**emergency response planning and business continuity planning** for identified **risks** should be addressed by the asset management system. All such incidents, including unanticipated events, should be investigated and reviewed to see if any improvements are needed to the asset management system, to prevent their recurrence and to mitigate their effects	**Improvements should be risk assessed** prior to being implemented.

Figure 26 - Asset mapping meta standard with 1192 and 212 mapped

PAS 185:2017		Principal Components	The security minded approa	e security context	Developing a smart city security strategy (SCSS)	Developing a smart city security management plan (SCSMP)	Security breach/incident management plan (SB/IMP)	Sharing and publication of data and information	Smart city projects
			Yellow: ***strategy and vision***						
			Magenta: ***data and information***						
			Green: ***investment and expenditure***						
			Blue: ***technical and technological***						
The need		This PAS specifies requirements for establishing a framework for the security-minded management of the city, including its associated assets, including data and information, and services.	Security minded approach is needed to respond to the vulnerabilities created by changes to existing ways of working without preventing delivery of the aims.	There is a need to mitigate against the reputational risks arising from security issues			If the provisions in the SCSS and SCSMP fail, smart city decision-makers shall consider the business continuity and disaster recovery scenarios that might affect the operation and viability of city assets utilizing digital technologies, or compromise sensitive data or information. A **security breach/incident management plan (SB/IMP)** should be created.		
The strategy		This PAS outlines methods for identifying **security threats** to a smart city, including those that might also affect the **people** who live, work in, trade from, or visit it. It also sets out parameters for mitigating other adversities on security **systems**.	Smart city decision-makers (3.1.56) shall, following the requirements of this PAS, determine the cityspecific, holistic **security-minded approach** to be adopted, addressing security around the aspects of **people, governance and accountability**, as well as **physical and technological security.**	To assist in the development of the city specific, security-minded approach, smart city decision-makers shall use suitable security guidance in order to gain advice on the security risks that arise through greater availability of data and information, integration of services and systems, and the increased dependency on IT-based systems.	Smart city decision-makers shall develop, document and maintain in a **SCSS (smart security strategy)**, the city's high-level requirements in relation to **protecting the security of assets (including data and information), services, and citizens**	Smart city decision-makers shall develop, document, implement and maintain a **SCSMP (smart city security management plan)** for the smart city that addresses the specific security risks or combinations of risks identified in the SCSS in a consistent and holistic manner.	Smart city decision-makers shall develop, document, implement and maintain a **SB/IMP** tailored to the **assets (including data and information)** and services that might be affected by a security breach or incident	**Prior to the sharing and/or publication of a new, or modified, city data or information set**, the owner of that data or information set shall apply the **data and information security triage process** (see Figure 5) to identify the need for a security-minded approach to be applied.	
The recommend	R1		The city-specific, security-minded approach shall take into consideration the **requirements of relevant organizations within the smart city** as well as those **service providers that directly interface with it**, even if, for the most part, their services are outside the city boundary.	smart city decision-makers shall gain an understanding of the range of threats that might seek to make use of **vulnerabilities**	The SCSS should be based on identification of the **assets** that are **critical** to the safety, security and wellbeing of citizens and the smooth and continuing operation of the city and the data and **information** that is held by an organization(s) associated with the city,in combination with an assessment of the state of that data and information	The SCSMP shall **identify the senior roles** at board or executive level within the relevant legal entities of the smart city that are **accountable for the governance of the agreed security policies and processes.** Where these legal entities change (see 4.1, Note 4), the SCSMP shall be updated to reflect this. NOTE The arrangements for setting up the governance	Smart city decision-makers shall set out the steps to be taken in the event of a discovery of a **security breach or incident**	In order to identify whether there are any personal data in the data set that the triage process is being applied to, the **personal data test** shall be applied	Prior to the commencement of a project or initiative that involves the creation, introduction, non-routine refurbishment, improvement or decommissioning of an asset, service, or the sharing of data or information, a project-specific security risk management plan shall be developed.
	R2		The city-specific, security-minded approach shall also be deliverable across the **contractual and service delivery arrangements** in place with the different service providers.	smart city decision-makers shall gain an understanding of the range of traditional and evolving techniques of **hostile reconnaissance** to which **asset-related, service-related** and **personal digital information** could be vulnerable;	The SCSS shall include the smart city **risk** management strategy determining potential threats, vulnerabilities, nature of harm,	The SCSMP shall nominate suitably qualified and experienced individuals within each city organization that has access to, uses and/or shares city data and information, to fulfil the role of a **smart city data officer (SCDO).**	Smart city decision-makers shall set out the steps to be taken in the event of a security breach or incident to contain and recover from the event	A data and **information sharing agreement**, available to all relevant parties, shall be put **in place prior to sharing of sensitive data or information** that could be used to cause harm to assets, services and/or individuals.	
	R3		In order to develop and implement a city specific, security-minded approach, a **formal mechanism shall be established for**: a) creating the required governance structure, b) appointing the smart city decision-makers; and c) reviewing and where appropriate updating the governance structure and appointments	the potential for, and potential impact of, malicious acts, including **sabotage,** caused by a range of **external and insider threats**, such as damage caused by m**alware, hackers** or disaffected personnel;	The SCSS shall address security around the aspects of people, governance and accountability, as well as physical and technological security.	7.3.1 Smart city decision-makers shall develop, record, implement and manage appropriate and proportionate **policies and processes relating to personnel and people security** and the embedding of a security-minded culture.	Smart city decision-makers shall establish a suitable mechanism for performing **periodic testing and review** of the **SB/IMP** to check that it remains fit-for-purpose.	9.1.3.2 Where city data or information is subject to any **access, licensing or distribution restrictions,** is being acquired from a source which has access restrictions, or is to be published, the relevant SCDO shall, in consultation with the data owner, establish an **appropriate and proportionate data and information sharing** agreement	
	R4			the potential for **insecure** or poorly maintained **systems** to leak, expose or permit unauthorized access to sensitive data and/or information;	The SCSS shall take into consideration relevant legislation and standards for the assets it comprises and the services it delivers, as well as the associated data and information	Smart city decision-makers shall develop, record, implement and manage appropriate and proportionate policies and processes relating to **physical aspects**			
	R5			e) the potential consequences of loss or disclosure of intellectual property and/or commercially sensitive data or information;	The SCSS shall identify the senior roles within the relevant legal entities of the smart city accountable for the governance of the agreed security requirements.	7.5 Data and information security Smart city decision-makers shall develop, record, implement and manage appropriate and proportionate **policies and processes** relating to **security-minded data and information management**			
	R6			f) the potential consequences of release of personal data	Smart city decision-makers shall establish a suitable mechanism for performing periodic reviews of the SCSS to identify and assess any security risks that have changed for political, economic, social, technological, legal or environmental reasons	7.6.1 Smart city decision-makers shall ensure that any service using city **data and/or information that identifies individuals or organizations:** a) is designed, built and operated using the NCSC guidance on digital service security [NR1]; and b) is subject to regular vulnerability assessment and penetration testing, determined by the processes used for maintaining situational awareness			
	R7			g) the potential impact of metadata integrity being compromised by corruption or unauthorized changes, or loss of access		The **accuracy, authenticity and long-term utility of data and information should be defined.**			
	R8			the potential impact of master referential data integrity being compromised by corruption or unauthorized changes, or loss of access;		7.8 Technological security 7.8.1 Smart city decision-makers shall develop, record, implement and manage appropriate and proportionate **policies and processes** relating to **technological aspects**			
	R9			how data and information can be used to conduct pattern-of-life analysis to facilitate malicious or criminal exploitation of habits, routines and preferences;		The SCSMP shall set out the appropriate and proportionate **monitoring and auditing** measures which shall take place throughout the lifecycle of the city,			
	R10			i) the increased risks and sensitivities that can occur through the aggregation of data or information,		Smart city decision-makers shall establish a suitable mechanism for performing **periodic reviews** of the SCSMP to check that it remains fit-for-purpose.			
	R11			the increased risks and sensitivities that can occur through the ability to derive new data and information by being able to analyse a wide range of existing data and information sources which might not have been previously available outside a smart city;					
	R12			smart city decision-makers shall gain an understanding of the impact and risks of making data or information available in real time;					
	R13			other adversities which can impact on the security systems in place; and					

Figure 27 - PAS 185 decomposition

Figure 28 - Updated PAS18x matrix before fusing PAS185


Smart City Standards Architecture towards AIM (Actionable Integrated Meta-standard)
A. Guiding principles
A. Smart Thinking
The Need
The Strategy
R1
R2
R3
R4
R5
Business case should be based on the critical success factors and account for potential risks
City vision should be driven by committed leadership
Benefits' owners made responsible for the benefit realisation plan and its budget
Cross-sectoral distributed leadership should be citizen-centric to collaboratively design customer functional services
City needs should be understood through a stakeholder engagement programme that includes customers and suppliers
Ensure outcomes-based digitally inclusive projects that use agile delivery methods
A common terminology and reference model for identity and privacy management should be created
Build a non-siloed resources and assets management IT architecture to enable reuse and sharing
Smart city's benefit realisation strategy should consist of benefit mapping and benefit tracking
Figure 29 - DBB meta standard concept (asset management competencies are marked with a red box around them)

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