Mapping Smart City Standards

Based on a data flow model

bsi.

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Acknowledgements

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Background

An overview of existing smart city standards would be of great benefit to the various actors involved in smart city projects, including local governments and technology companies, as well as standards developing organizations who are looking to create additional standards to help remove obstacles. Currently such an overview does not exist, and standards are still created and used mostly within the traditional silos.

This report describes a methodology for mapping existing smart city standards and providing an overview of these standards. A data flow model is used as inspiration for the search keywords and to help communicate the outcomes. The result of this mapping exercise is not just a list of existing standards and current initiatives, but it starts to form a 'map' of the landscape which is more insightful.

Methodology

Two stages can be distinguished in this study:

1. In the first stage, which is the focus of this report, standards are found by exploring databases and filtering relevant results.
2. In the second stage, these results can be made more easily discoverable by various stakeholders.

Together they reach the ultimate goal of knowing which standards are already available and who is working on them, learning where there are any gaps to design and implement new standards (while keeping in mind the relevant standards already available) and making it easy for various smart city stakeholders to identify which standards are available and applicable to them.

The search for standards was performed as follows: first, a smart city model was created to guide the selection of keywords and the design of search queries. Several smart city models published by technology vendors, cities and academics were examined and discussed, before a model was proposed to be used in this study. Next, lists of keywords were drawn up based on this model for 1) smart city application domains (e.g. transport or healthcare) and 2) smart city supporting fields (e.g. ICT) to produce initial results. Queries were then made using a combination of these keywords, which then led to standards which were categorized for both an application domain and an enabling field. Furthermore, a number of smart city topics (e.g. smart grid) were added to complete the picture. Results were manually filtered to remove those not relevant to smart cities.

After this initial phase, the methodology as well as the results of the mapping were presented to stakeholders (members of international standards bodies active in this field, as well as members of private and public sector organizations involved in smart city standards advisory committees) with the aim of receiving feedback on the applicability and usefulness. The input from the stakeholder consultation was positive, with support for the methodology and it was also widely agreed that such an overview of existing standards is really valuable, both for smart city stakeholders and for standards bodies, and that to date no complete picture exists. It was noted, however, that strategic and process standards were still lacking in the results.

Taking these suggestions on board, the keywords were revised and the following sets of keywords were used for the final searches:

- Fields supporting smart cities (Set A).
- Additional ICT keywords (to complement Set A).
- Smart city application areas (Set B).
- Smart city topics (Set C).
- City organizational terms (Set D).

- Smart city objectives (Set E).
- Project management and software management (Set F).

Based on these sets the following main queries could be performed:

1. (fields supporting smart cities (Set A) OR additional ICT keywords) AND Smart city application areas (Set B)

   Rationale: This query examines standards which are tagged with a field for a smart city supporting domain or ICT keyword (e.g. sensors or 'smart') as well as an application domain (e.g. transport or healthcare). The results should provide standards on how the supporting fields can be used in the various areas, with a focus on integration and interfaces.

2. Smart city topics (Set C)

   Rationale: This query looks at specific topics which may be relevant to the smart city (e.g. 'smart grid') using keywords which are not directly linked to ICS classifications. Standards returned will be directly applicable in those areas, but may also be useful for other related projects.

3. City organizational terms (Set D) AND Smart city objectives (Set E) AND Smart city application areas (Set B)

   Rationale: This query explores, for all smart city application domains, standards which are related to cities or their organization and decision-making processes as well as objectives of smart cities. Results give support for strategic issues as well as implementation.

4. City organizational terms (Set D) AND Project management keywords (Set F) AND Smart city application areas (Set B)

   Rationale: This query aims to find standards about project management which are relevant to stakeholder and decision makers in the city for the application areas considered here.

5. ICT keywords AND (City organizational terms (Set D) AND Smart city objectives (Set E))

   Rationale: Combining the specific ICT keywords with either organizational terms or objectives can bring forward standards where issues such as information exchange, automation and control and real-time are applicable to cities or any objectives for smart cities.

Findings

The searches have brought up a large number of standards relevant for smart cities. The majority of keyword combinations returned multiple standards, with some queries getting several hundred potential hits. Some queries found no standards, which could mean that no standards exist just yet for this combination or that the search is too specific (even though the more general terms might already be covered in other queries).

The report lists the number of standards retrieved for each keyword combination as well as the title of a typical example of a standard, while the full lists, organized by subject, are available at www.bsigroup.com/smartcitymapping. It turns out that the topics with the most standards are transport (in various categories including vehicles and road engineering), buildings: (standards related to buildings and devices within them) and environment (including issues such as air quality and waste). Many standards appear to be technical in nature and some very specific and only related to a particular device in a specific field. Especially with the additional keyword sets on smart city objectives and organization, relevant processes and strategic standards were also uncovered. There is also evidence that smart city standards currently under development, which aim to provide high level guidance and do not relate to a specific technical solution, will be found if these queries are repeated after they have been published. This further increases the confidence that the keywords and queries are successful in exploring relevant standards.

An overview of nearly 100 smart city standards is presented, including those standards that cross domains and decision-making levels. It is expected that these standards will have a direct impact on the design and implementation of smart city projects. The selection is produced by going through every list created during the study and picking those standards which are specifically about integrating two or more domains, about the decision-making processes and/or high level objectives. The aim is to provide a starting point for the more detailed analysis of the available standards.

This selection is grouped at three levels: technical (43 standards), process (29 standards) and strategic (17 standards). The technical standards are mostly about 'what' needs to be done in terms of implementation and/or operation. Process standards deal more with the 'how' and are related to actions or steps to be taken. Finally, strategic standards address 'why' and provide guidance for stakeholders in

planning and management. For each standard in the overview, the full title, document identifier and the publisher are listed. This overview gives a clear impression of the kind of topics addressed and the organizations working on developing standards.

Looking at the issuing bodies, for the technical standards ISO and IEC are especially active in a wide range of topics, in addition to standard bodies from Europe (national standards bodies including DIN, or NEN or institutes such as CEN, CENELEC or ETSI) while American standards are represented by ANSI and IEEE. A significant number of standards come from Russia (GOST R). Moving onto process standards, the influence of ISO and IEC is less visible and it is mostly European standards bodies who produce standards here. Again this includes CEN and CENELEC, but BSI, NEN and in particular VDI seem very active. Similarly, the strategic standards are less dominated by ISO. At this level BSI and CEN are the biggest contributors to smart city standards.

Recommendations

In the next stage the standards found in this study can be made more easily accessible to various stakeholders. To do this, each standard should be tagged with several relevant terms to allow it to be found when searching for a domain (or combination of domains), level of decision-making, type of guidance wanted, etc. The standards can be retrieved in various combinations, depending on the aims of the person searching. Instead of making all standards visible, only those which are relevant at the time are highlighted. While the underlying database can be the same, the visualization used could be different for types of actors, using multiple models so a world view they instantly recognize is available. This would make it easier to gain insights from the results.

Filtering the standards found in this study and making a selection of those relevant not just within one domain has been a manual task which could not be automated. It is recommended to revisit these lists with a team of domain experts who will be able to better judge the value and make a better-informed decision on the selection. These domain experts could also help in the classification of the standards, because they will know what people in their particular field might be looking for.

The topic of smart cities is moving quickly, and new standards are currently under development or can be envisioned. Repeating this study at regular intervals could be beneficial to make sure the findings are up-to-date. To aid in this, all the steps and complete lists of keywords and queries are provided in this report so the study can be replicated when necessary.

1. Introduction

Cities all over the world, from small regional communities to global mega hubs and from cities with an ancient core to brand new developments, are currently working on 'smart city' initiatives to make them more efficient, sustainable, more attractive to citizens and businesses and to encourage economic growth. However, there are many obstacles to successful implementation of these plans, and translating solutions from one place to another is difficult. While every city on earth is unique and has its own characteristics that will impact why, how and which smart city solutions may emerge, there are enough similarities for it to be worth investigating how best practices for financing, design, implementation and operation can be shared and how industry can re-use experience gained from earlier projects, for example. Key elements include interoperability of data between devices and subsystems, information flows between project partners, financing, risk management, etc. Standards for smart cities can support cities, (local) governments and industrial partners alike in removing some of these obstacles and lowering barriers.

To support the work of international standards bodies in this domain, a mapping exercise of existing standards relevant to smart cities has been proposed. This will lead to an overview of what is already available, insight into which standards bodies are active in which domains, and finally, it can result in identifying any gaps and opportunities. Such a review of standards should not just consist of a list of standards found but it has to offer some structure to be able to link domains and identify the interactions between the various elements of the smart city. To aid in this search a 'smart city model' is needed so identified standards can be mapped and linked. Furthermore, such a model would help set up a list of keywords to base the search on. With the right methodology the result of this mapping exercise will not just be a list of existing standards and current initiatives, but a 'map' of the landscape which is more insightful and relevant.

This document describes the methodology followed, a discussion of existing smart city models, a proposed overarching model, an initial search based on keywords identified from the model followed by a stakeholder consultation and updated searches resulting in an overview of smart city standards. A set of recommendations for follow-up work are provided, which includes a proposal for classifications of standards to help make them discoverable to a wide range of smart city stakeholders.

2. Approach and methodology

Two stages can be distinguished in mapping standards:

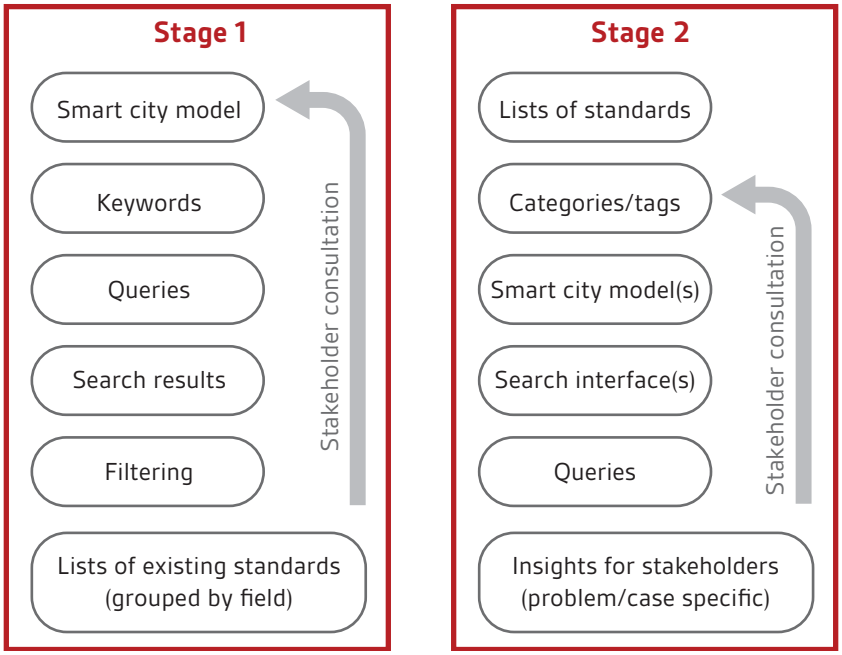
1) A 'searching' stage (Stage 1); and
2) A 'making accessible' stage (Stage 2).

Together they reach the ultimate goal of knowing which standards are already available, learning where there are any gaps to design and implement new standards (while keeping in mind the relevant standards already existing) and making it easy for various smart city stakeholders to identify which standards are available and applicable to them for the specific domains, levels and issues they are working on. Figure 1 illustrates the approach and the steps required for each of these two stages.

In the first stage the existing standards are found by running queries in databases and, after filtering the result, listing the findings based on the fields in which the searches were performed. The models used identify the relevant keywords and are selected and designed with that specific aim in mind. Stakeholder consultation is used to refine the approach and update the model and keywords based on feedback received on early results.

In the second stage, the standards found are categorized and 'tagged' so they can be found from various angles and results can be filtered to only show those which are relevant, depending on the role of the stakeholder and the types of standards he or she is looking for. Possibly a different model is required to visualize this so it is recognizable from the perspective of the stakeholders, and it is not unlikely that various models are needed to work for different actors. An interface to make these available and to guide the user in exploring the standards can be envisioned. The underlying data set, however, will remain the same, and it is key that the models used are at least consistent with one another.

Figure 1 — Schematic diagram of the approach for the two stages



NOTE In Stage 1 existing standards related to smart cities are found based on a smart city model. In Stage 2 the relevant standards are made accessible to specific stakeholders for specific cases through a search interface. This report focuses on Stage 1.

The focus of this report is on the first stage, leading to recommendations for the second stage.

To explain how the results were achieved and to make it possible to repeat these searches it is essential to describe the methodology followed. The first step is finding a suitable smart city model which can be used to derive keywords for the searches. A number of criteria for the smart city model need to be established which can be used to determine if models exist that can support this mapping exercise. If no suitable model can be found a new one will be proposed, where possible founded on elements from existing models. The following success criteria are suggested here:

- The model should be descriptive, not prescriptive. That means the model should, as best as possible, cover the breadth of existing and proposed smart city initiatives but not add any limitations as there is no one-size-fits-all smart city solution.
- The model should be useful to support a mapping exercise. It is not meant as a technical design for a smart city solution or smart city platform, but it should highlight relevant links between city domains and help suggest keywords for the overview study.
- Closely linked to the previous point; the model should enable identification of gaps in existing standard initiatives.
- The model should make clear how data and information flow through the city and between elements in the city.

This means that the model has to include a taxonomy of smart city components identified as well as the information flows between these elements of the model. The components can be mapped from different perspectives (e.g. organizational, technical, usage) and information flows can be considered between devices (e.g. technical interoperability) as well as actors (e.g. citizens, businesses, government) at various levels (from individuals, departments to whole organizations). By considering a smart city as a socio-technical system the interactions between the social and technical elements of the system can be taken into account as well, leading to a model applicable to the wide array of challenges as identified in Section 1.

After choosing a model, the second step then is deriving lists of search keywords based on the proposed model with which standards databases can be queried. Combinations of keywords lead to queries in step three, which, when executed lead to search results which have to be filtered manually for any irrelevant standards. Section 5.1 presents the approach followed for the searches in more detail. This then leads to lists of standards that may be useful to a wide range of smart city stakeholders.

Following the initial standards searches, a stakeholder consultation is performed. The methodology, examples of existing smart city models as well as the proposed models and keywords derived from them are presented together with an overview of the initial results. Two different audiences are sought for the stakeholder engagement step, namely:

1) Representatives of international standards bodies who are active in the smart city domain and involved in coordination activities at the European level[1]
2) Representatives of private and public sector organizations who are members of smart city standards advisory committees[2]

Feedback from this consultation can then be taken on board to adjust the model, keywords and queries before the final searches are performed and the results analysed.

1 Presentations given to members of the CEN/CENELEC 'Smart and sustainable cities and communities' coordination group in Brussels (16 October 2013) as well as the joint task group 1 and task group 3 meeting in Frankfurt (29 November 2013)

2 Participated in discussions at CapGemini/BSI event in London (8-9 October 2013) where an early version of this report was made available to members of BSI's 'Smart cities advisory group' and presentation given to the members of BSI's 'Smart cities technical interoperability committee' (21 November 2013).

3. Examples of existing smart city models

Models of smart cities are published with the purpose to communicate the idea and concepts of the smart city to other stakeholders, to aid in the (software) design and implementation phases or to help sell services and products. To reach target audiences a different angle can be taken in each model, highlighting certain elements or showing different levels of abstraction. Not each model will be directly useful or meet the criteria outlined above, but even high level presentations can inform a new design.

Smart city models are published by for example:

- technology firms operating in this area;
- cities in their proposals for smart city projects;
- researchers working on smart city projects at universities; and
- international standards bodies.

In this section several such models are discussed.

Several high-level models can be found, for example [3] (p.2) prepared by IBM or [2] (p.14) which is generated from Barcelona's smart city initiatives. The aim of these models is to sketch the context in which smart cities operate and make clear that various sub-systems have to be taken into account which are linked in some way. Concepts such as 'smart governance' and 'smart living' [2] feature in such models, introducing new elements which are still not fully defined but this does suggest that these elements can be considered more or less in isolation but will still influence one another. In the centre of this model is a circular arrow showing this influence, abstracting from how this will work and how this could be measured, and all concepts are encircled with 'infrastructure', 'human capital' and most notably 'information'. It is this information view which we are interested in. Also using a circular layout, [3] shows how citizens and businesses can be engaged to integrate services and it provides a context for the various stakeholders. Again, this high-level overview provides a scope but offers no detail in how the subsystems contribute to overall goals or even how the city's goals can be implemented. Of course models like these are not designed to reveal more detail, but one lesson that can be drawn from them is that the complete system is so big and complex that such extreme simplifications are required to try to communicate what the smart city entails.

IBM provides a very different perspective when giving an overview of the architecture of their Intelligent Operations Centre in [3] (p.15). Here a hierarchy of systems is shown with clear boundaries and interfaces; the city is split up into sectors such as water and transport each with their own gateway to send information to a central operations centre. This operations centre contains rules, models and workflows to integrate data from these subsystems to provide interfaces with simulation models, analytics and other data as well as visualization tools such as dashboards and alerts. This model also has a clear Problem Owner, namely the local government of the city, whose policies and key performance indicators are inputs to the control architecture. Where in the high-level smart city models nobody was in charge of any specific elements, here there is a clear purpose in the design. Information flows are key for this hierarchical representation, but it is not clear if the directional arrows used to link subsystems are meant to suggest information only flows one way. Analysing information across agencies and coordinating resources for efficient operation are main ingredients of IBM's vision for smart cities, but keeping the criteria in mind, what is missing from this model is a better indication of the information flows and the model offers a specific view and a specific solution.

Similarly, [8] (p.6) shows the architecture for Living PlanIT's Urban Operating System™. This model abstracts from the city's infrastructure systems by showing a layer of sensors and actuators which are considered to be external entities, but then describes in more detail various layers within the software architecture. The model includes a sensor and control interface which interacts directly with the sensors and actuators in the city, a control interface where data is integrated and aggregated, an interface with external data and applications and finally an application program interface (API) enabling 'apps' to interact with the platform. The model shows which interfaces there are so it gives insights into data flows, but it is only specific about the protocols for the actuator and sensor layer, while abstracting from any other explicit links between system elements.

Moving away from these quite technical models, an alternative is to address the steps city governments have to take to make sure smart city projects are a success, are fully integrated within the decision-making mechanisms within different departments and the result of a planned strategy. The smart city maturity model [6] describes how cities move in five phases from ad hoc and disconnected smart city initiatives to a situation where a full governance structure is in place to best support and deliver projects. The final stage includes a

city-wide platform for data integration and a smart city strategy integrated at all levels of decision-making and provision of funding. The maturity model describes the city's management and coordination with regard to smart city projects and provides suggestions for cities to improve and take a leading role. The stages can also serve as metrics to identify progress and compare cities. The model does not address technical city systems in particular, but does show that to reach the final stage integration of information flows is essential.

Rick Robinson emphasizes the need to consider smart city designs in context which requires an understanding of the environment in which smart cities exist [9]. He designed a schematic diagram to try to illustrate this context, providing a valuable overview by integrating most of the city systems mentioned earlier. This model includes goals, stakeholders, infrastructures and city systems. With its aim to provide context—and probably succeeding better than any other smart city model in doing this—there is no emphasis on any links between the subsystems through interfaces, data and information flows. Adding these to the model proposed in [9] possibly results in an image that is too complex, so it might be required to take the context from different perspectives so flows in each view can be shown more clearly.

The City Protocol Society, comprising cities, companies, academia and other organizations from all over the world, released an introduction to their City Protocol Framework [5] which is currently under development. The framework provides a consistent structure at different scales whether it is a device, building, neighbourhood, city or metropolitan area and its aim is to provide a common language to describe all features of cities. The basic idea behind the framework is that of a 'system of systems' where all elements in a city are a system made up of several other subsystems which interact with one another. This allows abstraction on different scales while giving sufficient power to describe all details at lower levels if they are relevant too: this works for objects (several of which can make up an apartment, several apartments form a building, several buildings create a block, etc.) as well as people (who join in all sorts of communities, organizations or other social structures). It is noteworthy that they separate 'services' from 'physical structures': for example, health is a service which can be provided in a physical structure called a hospital. The city is served by different infrastructures (namely information, water, energy, matter, mobility, nature) which each form their own 'ecosystem'. In this framework a platform can bring information from all these infrastructures and subsystems together, exchanging information from all levels.

The Technology Strategy Board[3] (TSB) in the UK invited cities to submit proposals for their Future Cities Demonstrator Programme with the aim to fund one city to enable them to make their vision a reality. Thirty shortlisted cities participating in this competition were invited to pursue and present a feasibility study and elaborate on the proposal. TSB analysed these thirty proposals [10]. Two views came out of this study which are of particular interest for the smart city standards' mapping exercise, because the report analyses and highlights the real challenges these cities face and the solutions that they proposed.

A diagram showing the integrated solutions from the proposals is presented in [10] (p. 21), containing four layers:

1) **Organization** with the stakeholders (e.g. citizens, local authorities, private sector).
2) **Infrastructure** with the support infrastructures such as wi-fi and broadband communication networks as well as sensors such as smart meters.
3) **Platform** dealing with data integration, visualization and in-home interfaces.
4) **Systems applications** showing the city infrastructures (e.g. energy, transport, education).

For each of the components of these layers, the report shows how many of the 30 proposals address this issue. From this overview common themes can be identified which many cities would want to address.

Taking this analysis forward, integration between sectors from these proposals is shown in [10] (p. 35). Here a diagram is presented linking the blocks from the systems application layer based on how many of the smart city proposals address a particular combination. We can learn, for example, that 12 out of 30 proposals want to address a combination of energy and transport systems, and eight link local economy and education. The model differentiates between integration of infrastructure-based sectors and service-based sectors with placement, but keeps them all together. As this model is based on the self-assessment of UK cities it gives great insights into the challenges which they hope to address with smart city solutions and can be a strong indicator of which links are likely. After all, it is this linking between sectors that differentiates smart cities from cities where smart things happen.

3 https://www.innovateuk.org/

4. Proposal for an overarching smart city model

Inspired by these models and keeping in mind the criteria and intended use of the model for the mapping exercise, a new smart model is proposed in Figure 2. This model has a mostly technical view, concentrating on how (sub)systems interact with each other supported by telecommunications and information technology.

The city is divided into the built environment (including homes, offices and shops and the devices within them), infrastructure-based sectors (e.g. energy and waste) and service-based sectors (e.g. healthcare and education). There is possible interaction between elements within any of these subsystems as well as between subsystems. Smart city infrastructure sectors, such as telecommunications, information technology and electronics, enable and support this interaction. A common theme in the example smart city models is the use of sensors to collect data from the city which, through platforms, can be combined, stored, analysed and displayed. This provides decision support for actors in the city who can then act and make changes, the effect of which can in turn be measured.

Figure 2 — A smart city model – technical view

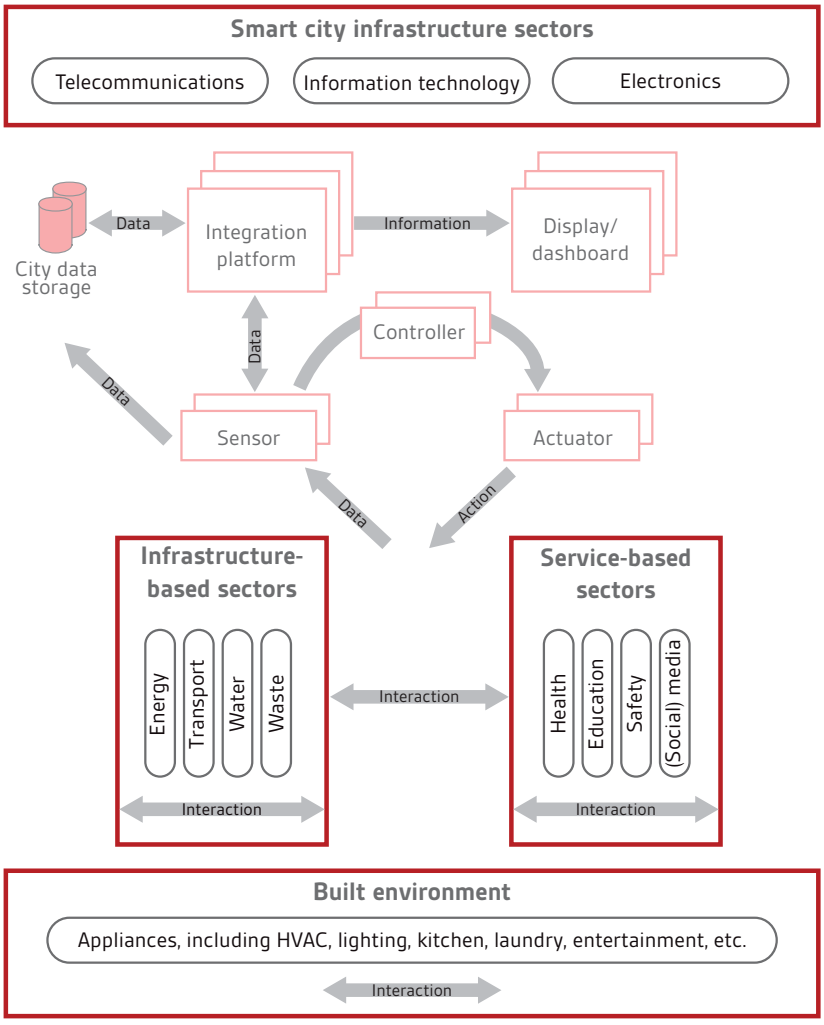
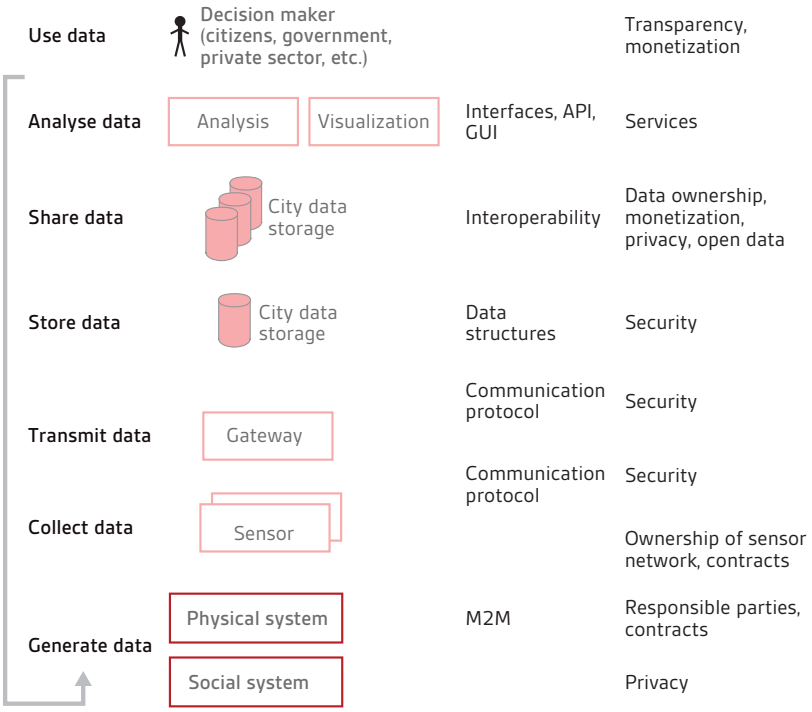


Figure 3 — A smart city model – data flow



A socio-technical perspective of this 'data flow' is illustrated in Figure 3. It shows how data is created in social and physical systems, collected, transmitted, stored and possibly shared before the data can be analysed, displayed and finally used to make decisions. At each step there are different actors involved (e.g. the person whose actions lead to new data, the owner of a sensor, the maintainer of a web platform, various owners of the data) and social as well as technical challenges to be addressed. Examples of these challenges are given on the right, with the first column highlighting a few technical challenges (e.g. related to interfaces and interoperability) while the second shows a number of social issues (e.g. privacy, security, monetization). Such data flows can be observed within as well as between the systems shown in Figure 2.

Without making the individual actors and subsystems specific, this high level and generic view of data flows can hopefully help to understand where standards could be found. In the next section, keywords are suggested based on Figures 2 and 3 to start the search for smart city standards.

5. Initial standards search

In this section an initial search of existing standards is performed keeping these models in mind to select the relevant search keywords and display the results graphically. This study is performed in close cooperation with Lucy Ahmed and David Serrano of BSI's Knowledge Centre.

5.1 Approach

A list of keywords are prepared with which databases holding existing standards will be queried. The keywords are based on the proposed overarching smart city model, with a particular focus on the relationships between system components and interoperability between silos through data flows. This list of keywords will be refined through a series of searches. First, only the number of matches returned from an initial keyword search is considered. This is used as an indicator for whether the search is on the right track: if some searches result in a few hits where some existing work was expected, the wrong keywords may have been used, and if other queries result in an unexpectedly large number the selected keywords may have been too generic. If this results in any surprises an attempt can be made to explain why this is the case, and then either refine the model and/or keywords or at least understand its limitations better.

Once satisfied with the initial results and the explanation of where any surprises come from, the particular standards found can be examined in more detail. They have to be manually filtered and classified. This classification might include:

- parts;
- processes; and
- behaviour,

but could be adjusted based on the actual standards found and the input from the stakeholder consultation. This classification is beyond the scope of this study, but initial suggestions for a structure that could be used will be provided.

The 'Perinorm' database[4] is used to perform all queries. It is 'the world's leading bibliographic database of national, European and international standards from more than 200 standards publishing organizations in 23 countries, with a total of more than 1,400,000 records' and only current standards are included (i.e. any withdrawn standards or those replaced by newer ones are excluded).

5.2 Keywords

For the identification of keywords, the ICS (International Classification of Standards) structure is used [7]. This is a hierarchical classification containing 40 fields at level 1, further detailed in 392 groups at level 2 and finally 909 sub-groups at level 3. Which category is chosen depends on the subject of the standard. Standards may be allocated to more than one category, but it is recommended that a situation where a standard has more than four classifications is avoided. Standards may be placed in more than one field. In this study, where the interface between city systems is of particular interest, standards which fall in more than one field in this classification might indicate some form of interaction between fields.

4 http://www.perinorm.com/

5.2.1 ICS fields for smart cities

With the models from Section 4 in mind, at the highest level, the following fields are likely to contain (currently or in the future) standards relevant to smart cities:

- 03 SERVICES. COMPANY ORGANIZATION, MANAGEMENT AND QUALITY. ADMINISTRATION. TRANSPORT. SOCIOLOGY
- 11 HEALTH CARE TECHNOLOGY
- 13 ENVIRONMENT. HEALTH PROTECTION. SAFETY
- 27 ENERGY AND HEAT TRANSFER ENGINEERING
- 29 ELECTRICAL ENGINEERING
- 31 ELECTRONICS
- 33 TELECOMMUNICATIONS. AUDIO AND VIDEO ENGINEERING
- 35 INFORMATION TECHNOLOGY. OFFICE MACHINES
- 43 ROAD VEHICLES ENGINEERING
- 45 RAILWAY ENGINEERING
- 55 PACKAGING AND DISTRIBUTION OF GOODS
- 91 CONSTRUCTION MATERIALS AND BUILDING
- 93 CIVIL ENGINEERING
- 97 DOMESTIC AND COMMERCIAL EQUIPMENT. ENTERTAINMENT. SPORTS

With smart city technology leaning heavily on information and communication technology and considering the importance of data flows in this study, fields 29, 31, 33 and 35 are considered as supporting fields while the others (i.e. 03, 11, 13, 27, 29, 43, 45, 55, 91, 93, 97) represent fields for which smart solutions exist or can be envisioned in the context of cities. At the cross-section of these two sets interesting combinations may be found.

For each of these 14 fields, a subset of groups relevant to smart cities is provided in Sections 5.2.2 and 5.2.3. This list requires further review, for example during the stakeholder consultation phase, but serves as a starting point for reducing the number of hits and filtering out aspects which are not likely to be related to smart cities or data and information flows in cities.

5.2.2 Keywords for fields supporting smart cities (Set A)

For Set A (fields supporting smart cities) the following list of groups is taken:

- 29.120 Electrical accessories
- 29.130 Switchgear and controlgear
- 29.240 Power transmission and distribution networks
- 31.120 Electronic display devices
- 31.220 Electromechanical components for electronic and telecommunications equipment
- 33.020 Telecommunications in general (including infrastructure)
- 33.030 Telecommunication services. Applications (including supplementary services, service aspects and associated legal traceability aspects)
- 33.040 Telecommunication systems (including network (system) aspects)
- 33.070 Mobile services

- 33.120 Components and accessories for telecommunications equipment
- 33.200 Telecontrol. Telemetering
- 35.020 Information technology (IT) in general
- 35.080 Software
- 35.110 Networking
- 35.200 Interface and interconnection equipment
- 35.240 Applications of information technology

5.2.3 Keywords for smart city application areas (Set B)

For Set B (smart city application areas), the following groups are most relevant:

- 03.080 Services
- 03.220 Transport
- 11.020 Medical sciences and health care facilities in general
- 13.020 Environmental protection
- 13.030 Wastes
- 13.040 Air quality
- 13.060 Water quality
- 13.200 Accident and disaster control
- 13.320 Alarm and warning systems
- 27.010 Energy and heat transfer engineering in general
- 27.080 Heat pumps
- 27.160 Solar energy engineering
- 43.020 Road vehicles in general
- 43.040 Road vehicle systems
- 43.060.50 Electrical and electronic equipment. Control systems
- 43.080 Commercial vehicles
- 43.100 Passenger cars. Caravans and light trailers
- 43.120 Electric road vehicles
- 43.160 Special purpose vehicles
- 45.020 Railway engineering in general
- 45.040 Materials and components for railway engineering
- 45.080 Rails and railway components
- 55.180 Freight distribution of goods
- 55.230 Distribution and vending machines
- 91.020 Physical planning. Town planning
- 91.040 Buildings
- 91.140 Installations in buildings

- 91.160 Lighting
- 91.190 Building accessories
- 93.010 Civil engineering in general
- 93.080 Road engineering
- 93.100 Construction of railways
- 93.120 Construction of airports
- 93.140 Construction of waterways, ports and dykes
- 97.020 Home economics in general
- 97.030 Domestic electrical appliances in general
- 97.040 Kitchen equipment
- 97.060 Laundry appliances
- 97.080 Cleaning appliances
- 97.100 Domestic, commercial and industrial heating appliances
- 97.120 Automatic controls for household use
- 97.130 Shop fittings
- 97.180 Miscellaneous domestic and commercial equipment
- 97.200 Equipment for entertainment

5.3 Initial exploratory queries and revision of keywords

For the exploratory query combinations between these two sets, a list is created for each of the 43 fields from Set B with all standards that are also classified with one of the 16 supporting fields from Set A, providing an overview of how standards related to smart cities are emerging for these fields. As indicated in Section 5.1, after a first search using the queries based on the above mentioned ICS keywords only, the results were compared with expected outcomes as well as the results of earlier smart city standards reviews performed by BSI. The results found using these two sets were mostly highly relevant to the domain, but it was also clear that some additional keywords would be beneficial to address sectors not yet fully covered. These additional keywords were based on the models from Section 4, browsing the standards database for known subjects and examining which keywords were used for these.

5.3.1 Additional ICT keywords (to complement Set A)

In addition to Set A, the following ICT related keywords were used to perform the full searches:

- Interoperab*
- Interchang*
- Information
- Data
- Interface
- Smart
- Intelligent
- Communicat*

- Exchange*
- Transfer*
- Application*
- Automat*
- Messag*
- eSafety
- Protocol*
- Real-time
- Realtime
- Contactless
- OpenADR
- Cyber*

These keywords cover specific elements of smart city applications and implementations which can be applied to various domains and can be used in addition to Set A (for each of the groups from Set B).

5.3.2 Keywords for smart city topics (Set C)

Furthermore, a number of topics were identified which were not fully covered by the ICS keywords in Set B. These are subjects which in their own right are relevant and do not need to be combined with keywords from Set A or the ICT related keywords listed above. Again, these additional keywords were based on the proposed models, the results of earlier studies and by considering common descriptors used when standards were added to the database.

The list of topics in Set C is as follows:

- Smart grid*
- Smart sensor*
- Smart meter*
- Assisted living
- Smart cards (Card operating system)
- Biometric*
- Secure industrial control systems
- Personal identity verification
- Open data
- Cyber security
- Machine readable travel documents (MRTD)
- Social media
- Domotic*
- Dashboard
- Displays

As this list of topics is more general and is not combined with other keywords there is a risk that more irrelevant results would be brought up which will have to be manually removed afterwards. There may also be some overlap with the results from the combination of Set A (plus additional ICT keywords) and Set B.

5.4 Queries performed

1. Fields supporting smart cities (Set A) OR additional ICT keywords AND smart city application areas (Set B)

   Rationale: This query examines standards which are tagged with a field for a smart city supporting domain or ICT keyword (e.g. sensors or 'smart') as well as an application domain (e.g. transport or healthcare). The results should provide standards on how the supporting fields can be used in the various areas, with a focus on integration and interfaces.

2. Smart city topics (Set C)

   Rationale: This query looks at specific topics which may be relevant to the smart city (e.g. 'smart grid') using keywords which are not directly linked to ICS classifications. Standards returned will be directly applicable in those areas, but may also provide useful for other related projects.

3. Exploratory query: additional ICT keywords AND (Ergonomics OR Government OR Governance)

   Rationale: Because most of the keywords used in Set C were purely technical, with this search a first attempt is made at identifying some of the human factors when linked to the ICT keywords (e.g. open data combined with government). This can lead to identifying additional keywords based on found standards.

Duplicate results are removed based on the title of the standard without conscious choice of which one to keep (e.g. the international standard or the one adopted by a national standards body). If duplicates are found under more than one field these are not eliminated but preserved; removal of duplicates are only done for each individual query.

5.5 Results

An overview of the results of the queries for each keyword from Set B combined with any from Set A or the additional ICT keywords is shown in Table 1. For each category the number of standards found in the database is given, as well as an example of a standard from these results. Titles of example standards have sometimes been truncated to improve legibility. It should be noted that the number of standards listed here is the outcome of a manual filtering process (which removed an estimated 10 % of results) and still includes a number of results which are potentially relevant but flagged up as 'unlikely' without removing them from the results. The numbers presented here should thus be seen as an upper bound for those standards applicable to the smart city for each subject. The full list of all standards retrieved, including document identifier and publisher, can be found at www.bsigroup.com/smartcitymapping.

Table 2 shows the results of the searches for specific smart city related subjects. These searches are only for the keyword in the title of the standard, not using any combinations of search terms. Again the number of published standards is given, with the same caveat about relevance, as well as an example of a typical standard in the list. The full list is available at www.bsigroup.com/smartcitymapping.

Finally, the searches for standards developed by other organizations not included in the Perinorm database resulted in several standards covering

- smart grid;
- smart standards on energy;
- smart cards;
- web standards by W3C;
- wireless networking; and
- intelligent transport systems.

Most of these domains are also covered by the keywords used above, but through this additional study more standards were found. The W3C (World Wide Web Consortium[5]) is responsible for the standards behind the internet including for example the Hypertext Transfer Protocol (HTTP), HTML markup for websites and the XML data structure, but related to smart cities there are particularly relevant links with standards related to linked data, the semantic web, e-Government and open data.

5 http://www.w3.org/

Table 1 — Results of keywords searches Set B + (Set A or additional ICT keywords)

Topic (Set B)	Quantity	Example standard
03.080 Services	159	Criteria for design, management and control of maintenance services for buildings
03.220 Transport	504	Intelligent transport systems – Automatic vehicle and equipment identification
03.220 Medical	81	Electronic exchange of messages with prescriptions and dispensations
13.020 Environment	93	Data exchange between ERP systems and environmental information systems
13.030 Wastes	52	Data structures for electronic data interchange in the field of waste management
13.040 Air quality	67	Air quality – Exchange of data
13.060 Water quality	34	Wastewater treatment plants – Control and automation
13.200 Accident	30	Emergency services messaging interface
13.320 Alarm	102	Message formats and protocols for serial data interfaces in alarm transmission systems
27.010 Energy	26	Framework for energy market communications
27.080 Heat pumps	7	Product data exchange in the building services
27.160 Solar	46	Characteristics of the utility interface for photovoltaic (PV) systems
43.020 Road vehicles	23	Intelligent transport systems – Automatic vehicle and equipment identification
43.040 Road vehicle systems	282	Public transport – Road vehicle scheduling and control systems
43.060.50 Control systems	10	Bluetooth wireless protocol for automotive applications
43.080 Commercial vehicles	28	Interoperability guide to DTQM operations using a smart card.
43.100 Passenger cars	1	Specification for security systems against theft of in-car equipment for entertainment and communication purposes
43.120 Electric vehicles	32	Communication between plug-in vehicles and the utility grid
43.160 Special purpose	10	Winter and road service area maintenance equipments – Data acquisition and transmission in vehicle-data acquisition
45.020 Railway	21	Communication means between safety equipment and man-machine interfaces (MMI)
45.040 Railway materials	16	Intercommunication between vehicles and train/wayside
45.080 Railway components	0	–
55.180 Freight distribution	38	Freight containers – Automatic identification
55.230 Vending machines	16	Public transport passenger information
91.020 Physical planning	6	Open data communication in building automation, Controls and building management
91.040 Buildings	40	Building automation and control systems
91.140 Installation in buildings	271	Building automation and control system (BACS)
91.160 Lighting	10	Home electronic system (HES) application model – Model of an energy management system for HES
91.190 Building accessories	12	Automatic electrical controls for household and similar use
93.010 Civil engineering	2	Communication and public participation in planning and building of infrastructure projects
93.080 Road engineering	119	Road equipment – Data capture stations

Topic (Set B)	Quantity	Example standard
93.100 Railways	31	Communication, signalling and processing systems – Safety related electronic systems for signalling
93.120 Airports	15	Advanced surface movement guidance and control system
93.140 Waterways	3	Security management systems for the supply chain – Electronic port clearance
97.020 Home economics	8	Open data communication in building automation, controls and building management – Home and building electronic system
97.030 Electrical appliances	6	Household appliances interworking – Part 2: Data structures
97.040 Kitchen	0	–
97.060 Laundry	0	–
97.080 Cleaning	0	–
97.100 Heating appliances	13	Particular requirements for temperature sensing controls
97.120 Automatic controls	133	Specification for automatic electrical controls for household and similar use
97.130 Shop fittings	0	–
97.180 Misc equipment	7	Design criteria of integrated sensor-based test applications for household appliances
97.200 Entertainment	38	Information-telecommunication game systems – Functioning control

Table 2 — Results of keywords searches Set C

Topic (Set C)	Quantity	Example standard
Smart grid	9	Applicability of M2M architecture to smart grid networks
Smart sensor	12	Capabilities of ubiquitous sensor networks for supporting the requirements of smart metering services
Smart meter	13	Electricity metering data exchange
Assisted living	11	User interaction in multimedia ambient assisted living spaces
Smart cards	112	Smart card system – Interoperable citizen services
Biometrics	106	Data format for the interchange of fingerprint, facial and other biometric information
Secure industrial control systems	84	Digital enhanced cordless telecommunication (DECT)
Personal identity verification	7	Biometric profiles for interoperability and data interchange
Open data	10	Open data communication in building automation, controls and building management
Cyber security	22	Smart device communications – Security aspects
Machine readable travel docs	27	Advanced security mechanisms for machine readable travel documents
Social media	4	Guidelines for business-to-consumer electronic commerce transactions
Ergonomics	42	Ergonomic aspects of transport information and control systems
Government	7	EU e-Government metadata framework
Dashboards and Displays	86	Public transport passenger information

The wireless networking standards include those by the Institute of Electrical and Electronic Engineers (IEEE) for communication protocols such as Wi-Fi, Bluetooth and Zigbee which may be used for communication between smart city devices including sensors and tablets. A long list of the Global System for Mobile Communications (GSM) is also available, dealing with communication between mobile devices such as mobile phones.

For the topic of Intelligent Transport Systems standards it is worth pointing out the European Telecommunications Standards Institute (ETSI), which has developed standards for communication, signalling, applications, data transmission, security, etc.

For a more detailed description of the searches on private and other standard developing organizations please see www.bsigroup.com/smartcitymapping for a report from the Knowledge Centre.

5.6 Analysis

The proposed approach has led to a large number of standards which may be relevant to smart cities. All keywords or keyword combinations have returned standards which appear to fit the requirements. However, they have also produced lists of standards which are not particularly relevant to the kind of interactions between components at various levels of the city envisioned in smart city initiatives. Filtering these out has been a labour-intensive manual process.

A rough estimate suggests about 10–20 % of standards found with the keywords in Table 1 could be immediately discarded while this rose to around 30–40 % for the results in Table 2. Judging which standards are indeed relevant is often hard based on just the title, abstract and descriptors or without expert knowledge in all fields. So while the results have clearly produced many highly relevant standards, including those used as examples in Tables 1 and 2, further analysis of the results is required before a full picture of the scale of available standards can be given. Taking the views of various stakeholders and domain experts on board should help to further trim these lists down.

Having said that, with the current results, a clear picture is beginning to emerge with a large number of standards in fields which are indeed often the focus of smart city proposals such as transport, installations in buildings and the environment:

Transport: over 1000 standards found in various categories including vehicles and road engineering

Buildings: more than 450 standards found related to buildings and devices within them

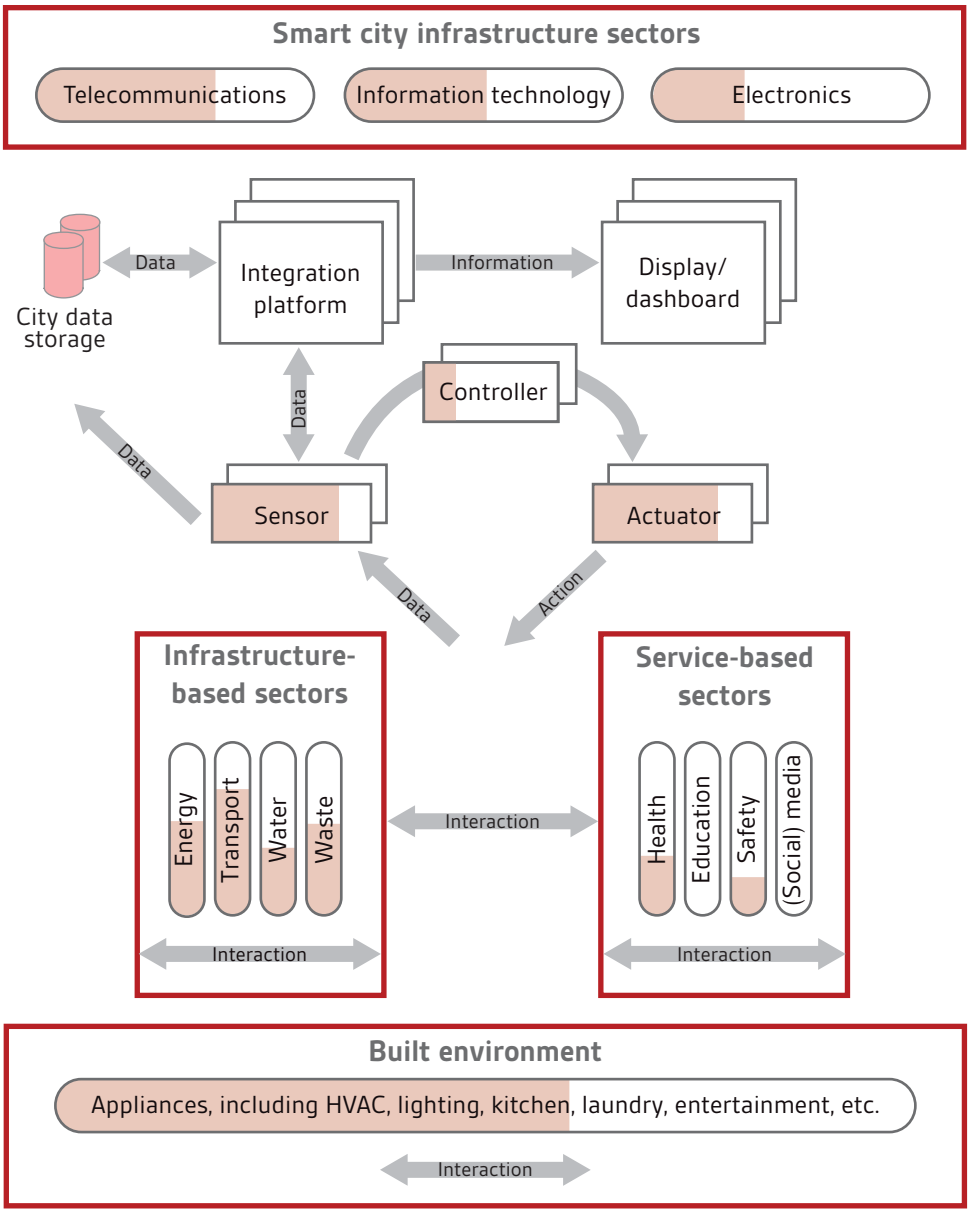
Environment: nearly 250 standards found related to the environment and issues such as air quality and waste

Other large categories include medical (81 standards found) and energy (79 standards found).

The search using specific smart city subjects shows that smart cards, biometrics, displays, secure control systems and ergonomics are key areas for which standards have been developed, with little (yet sometimes highly relevant) activity in other domains. It must be questioned whether all these results are equally related to smart cities, especially since some appear only directly useful in their own discipline. For example, the standards on biometrics as a means to provide secure access to services or devices are very specific and not directly linked to other domains; more important would be how the data or devices to which access is granted are linked up. It is relevant that there are standards to enable this specific method of security, but the details are of limited importance. On the other hand, for the smart card standards there is a clear aim in the standards to provide access to services across different domains (e.g. seamless travel, health, payments).

The large majority of these standards relate to the technical part of smart cities, with very few results for 'softer' elements such as the engagement of citizens in the government's decision-making processes. Going back to Figure 2, there are many mature standards for the smart city infrasturcture sectors such as telecommunication which can facilitate the development of smart cities, and a large number of initiatives in the infrastructure-based sectors as well as the built environment, but there are few focused on the service sectors (perhaps with the exception of security). Interaction between devices and actors within systems is often addressed by standards, but standards for the interaction across sectors are still rare. Links between energy and transport (e.g. electric vehicles) can be found, but that is because those are embedded in the system which could not work otherwise. Figure 4 attempts to illustrate, relative to the other topics, where most standards found in this study so far can be located.

Figure 4 — Standards mapped on the smart city model: technical view



6. Stakeholder consultation

The next step is to take the model and the results of the initial mapping to stakeholders with the aim to receive feedback regarding the applicability and usefulness. The outcome of this wider consultation will then feed back to the model as well as the keywords used in the search so that both can be refined if required. With these initial results, a stakeholder consultation was performed, gaining feedback from members of international standards bodies active in this field as well as members of private and public sector organizations involved in smart city standards advisory committees.

An early version of this report was made available to members of BSI's 'Smart cities advisory group' during the CapGemini/BSI event (8–9 October 2013, London) and a presentation was given to the representatives of international standards bodies who participate in the CEN/CENELEC 'Smart and sustainable cities and communities' coordination group (16 October 2013, Brussels). Next, the work was presented to the members of BSI's 'Smart cities technical interoperability committee' (21 November 2013, London) and feedback from the two earlier presentations was added. Finally, the smart city models and methodology were revisted in a presentation given at the CEN/CENELEC 'Smart and sustainable cities and communities' joint meeting of Task Group 1 and Task Group 3 (29 November 2013, London).

The feedback from the stakeholder consultation was positive, with support for the methodology and the use of ICS classifications to formalize the keywords in particular as well as keen interest in the various smart city models presented and their inspiration for the proposed model. It was also widely agreed that such an overview of existing standards is really valuable, both for smart city stakeholders and for standards bodies, and that to date no complete picture exists.

It was noted, however, that strategic and process standards were still lacking in the results. Part of the reason is that fewer can be expected as there are not as many relevant standards published in this area, but there were concerns that the model from Figure 2, which was mainly used for the creation of the list of keywords in Set A (smart city supporting fields), Set B (smart city application areas) and the additional ICT keywords, represents a technical view of the smart city field (see also Section 5.6). Indeed, during the initial searches the socio-technical aspects of the model had not been fully developed and smart city objectives had not been taken on board.

Looking backwards, i.e. looking up standards in the database or online and trying to find which keywords would have been required to discover it during new searches, proved a valuable way forward. As an example, the work of ISO/TC 268 ('Sustainable development in communities') was considered.[6] This group is currently working on various standards which will be published in the near future, but they have already indicated under which ICS codes the work will be filed: 13.020 Environmental protection.[7] This code was already included in Set B (Section 5.2.3) which means that if the work had been published it could have been found.[8] This gives further confidence that the approach followed can lead to a successful overview of relevant smart city standards not only with a technical emphasis but also including higher level strategic and process standards.

In addition to this, standards on Building Information Management (BIM) systems were also considered as an example. During the initial searches several BIM standards were found, but there was evidence that more standards should have come up. The BIM standards found so far were classified under ICS code 91.040 (Buildings) but using the reverse look up it became clear that the majority of BIM standards can be found under ICS classification 91.010 (Construction industry) which was a group that was previously dismissed. Adding this group to Set B while keeping the rest of the queries the same will then lead to new relevant results. BIM standards were also found to be classified under 35.240 (Applications of information technology) which was already included in Set A.

Looking specifically for smart city solutions in healthcare, ICS code 11.180 (Aids for disabled or handicapped persons) has to be added to Set B. Furthermore, 03.060 (Finances. Banking. Monetary systems. Insurance), 03.100 (Company organization and management) and 03.120 (Quality) have to be explored to see how relevant standards for funding, procurement, project management and quality control can be found. There was also feedback about the importance of services as well as smart city objectives such as sustainability, so 03.080 (Services) and 13.020 (Environmental Protection), which both were already in Set B for the first phase, will be studied in more detail and in new keywords combinations.

6 Proposed as an example during the CEN/CENELEC coordination group meeting on 16 October.

7 Or, as 13.020 is listed on the ISO website, 'Environmental economics, including sustainable development'.

8 See for example ISO/PRF TR 37150 'Smart community infrastructures – Review of existing activities relevant to metrics' prepared by ISO/TC 268 and currently in the approval stage.

During the stakeholder consultation it was acknowledged that the general approach followed here and the use of a smart city model as a foundation for searching as well as making available standards was helpful, and in fact might work in other domains as well. CEN, CENELEC, and ETSI had been working on a similar project, but focused on the smart electricity grid and for this a 'Smart Grid Reference Architecture' was developed [4]: the 'framework and its methodology are intended to present the design of smart grid use cases in an architectural viewpoint allowing it both-specific but also neutral regarding solution and technology'. Furthermore, it 'allows the validation of smart grid use cases and their support by standards'. As part of this work a 3D model was proposed, with along the axes different domains (e.g. generation and transmission) and zones (ranging from process to market). On top of this plane different cross-cutting interoperability layers are added, from component to business. These layers are inspired by the Open Systems Interconnection (OSI) model (ISO/IEC 7498-1) which has seven layers from a physical to an application layer. If this can be interpreted as interoperability between systems in different domains it could provide a solid foundation for addressing the levels in a well-defined way. A website has been created[9] which allows people to identify which smart grid standards are needed for a specific project.

As a follow on from this project, VDE/DKE are preparing a smart city model taking the basic design from the smart grid model but changing the content to fit the wider context of smart cities. For example, the domains are extended to various city infrastructure systems including transport and healthcare. This model is currently under development. Their smart city model is also mostly technical, for which it appears very promising, but lacks in social elements such as different actors, aims and objectives. A main lesson to be taken from this work is the formal approach to include use case descriptions to design the model and to validate it. A quick exercise[10] to map case studies onto this model, however, proved to be difficult without the right domain experts and sufficient preparation. Also, combinations of domains were difficult to visualize because they were on one axis. This is easier within the smart grid context since, even though it is a complex system with many actors and physical elements, it is all within the same field of energy. Still, the approach and visualization are very useful and if the right graphical user interfaces are designed to complement this work, making standards visible, that would be a really valuable contribution. Together with a team of domain experts this model can be further refined, extended, validated and tested.

Several other standards that did not come up in the searches were suggested during the stakeholder consultation and they are briefly discussed below.

The Open Group Architecture Framework (TOGAF),[11] a standard developed by the Open Group, is an 'enterprise architecture methodology and framework used by the world's leading organizations to improve business efficiency'. It is used to create formal descriptions of an information system, in particular by defining components or building blocks and how they will work together. The standard might be relevant for smart cities as initiatives are often about integration and interconnection, and TOGAF could help describe not only how the overall system works together but also how individual components can be designed and developed independently (e.g. by multiple vendors) in a way that they can be connected successfully. This standard leads to several suggestions for additional keywords to consider in the searches, such as:

- enterprise architecture;
- business architecture;
- application architecture;
- data architecture or information architecture.

TOGAF does not cover the last three items specifically, so possibly alternative standards can be found for them. An initial search should make clear if these indeed give new useful results, or that they are too specific and will not help identify smart city standards. The Open Group should also be added to the list of private standards bodies to investigate, see http://www.opengroup.org/subjectareas.

The IEEE Concept of Operations (ConOps) standard (IEEE Std 1362-1998 (R2007)) helps organizations develop a requirements document describing the existing 'software-intensive' systems, the rationale for modifications or a new system and finally the proposed new system. The standard describes a vocubulary and the elements that need to be addressed in such a document. This does not have to be a smart city specific system, but given the scope it could be a productive way to manage changes and capture requirements in a useful fashion. Additional project management keywords could also be derived from this and similar standards.

9 http://www.iec.ch/TESTS/smartgridmap/

10 At the CEN/CENELEC 'Smart and sustainable cities and communities' joint meeting of Task Group 1 and Task Group 3 (Frankfurt, 29 November 2013).

11 See http://www.opengroup.org/togaf/.

7. Updated smart city model

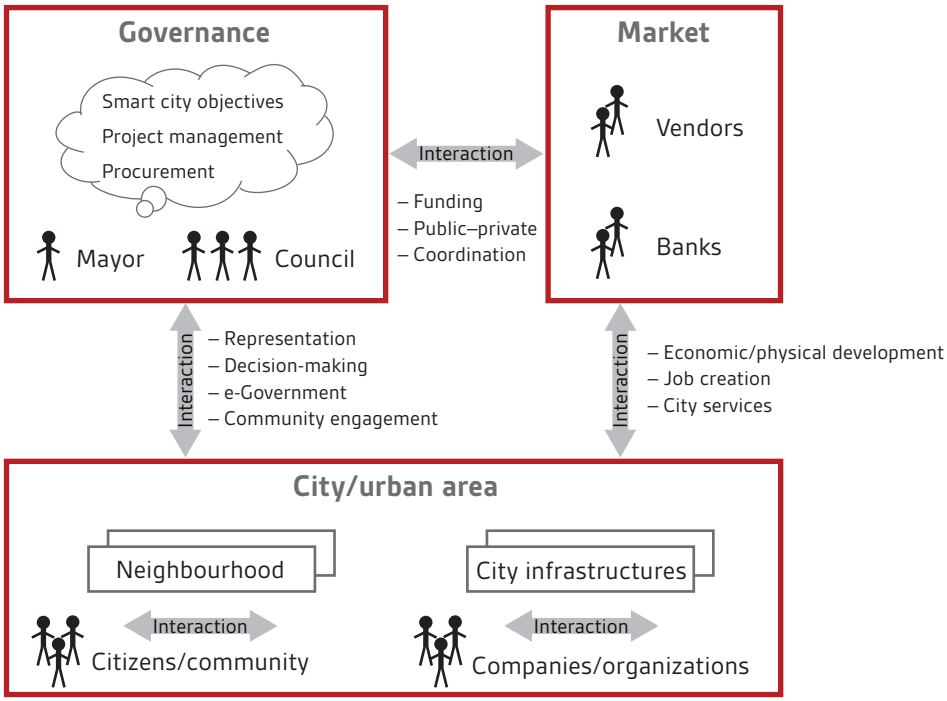
Taking the stakeholder feedback into account, an updated model is proposed to cover the different city actors, their organization, as well as smart city objectives. Instead of considering data flows as a technical idea, here the social interaction between the different stakeholders has the emphasis. Figure 5 shows the city (or urban area) within which the systems from Figure 2 reside.

Citizens and the community in neighbourhoods within the city are represented and governed by city leaders (often in the form of a mayor) supported by local authorities or councils. Guided by smart city objectives such as creating a more transparent way to govern the city, increasing the number of jobs or improving sustainability, projects can be managed and funding for them sought, in close cooperation with the market. Through the market technology vendors, banks and other companies provide services and jobs for the city.

This model, in combination with the figures from Section 4, can be used to further derive keywords for the updated search. It must be said that it is a high level and fairly abstract view, which does not fully capture all relationships and stakeholders in the city. A precise model in which all actors are mentioned explicitly and all connections visualized would not only be very difficult to design, as can also be observed when analysing the other models in Section 3, but it is also not required for the selection of keywords for the mapping study. Looking at higher level roles and activities (e.g. decision-making, procurement or management) in combination with the domain classifications should already result in the appropriate standards without having to search specifically for a certain type of decision, procurement method or management approach.

To visualize the findings for stakeholders and make the results of the standards mapping accessible, it will be important to design models which these stakeholders recognize easily. In that case it may be needed to design multiple models to match the various viewpoints and angles. In such a model the actual actors and their roles can and should be made specific. For Stage 1 of the mapping (see Figure 1) the next step now is to update the keywords which is done in Section 8.

Figure 5 — Smart city model – Social view



8. Updated standards search

Following the input from the stakeholders as described in Section 6, another round of searches is conducted with updated keywords. Just like the first round of searches (Section 5) the second round was also executed in close cooperation with BSI's Knowledge Centre who performed the actual database searches.

This section lists all keywords used in the updated searches, as well as the results and an analysis of the findings. The approach from Section 5.1 was followed here too, which means the lists of keywords were updated based on a quick analysis of the results in an iterative process. Because these are new sets of keywords, new iterations are required. The number of standards retrieved in this fashion can be a guide to what changes are still required, particularly if there are too many hits in the database. Additional search keywords were, for example, derived from the keywords used in the database for particularly relevant standards, if it appeared key results were still missing or if there were few hits where more were expected. If there is only a low number of results the keywords should still be kept in case these categories are eventually populated by new standards, some of which are currently under development.

8.1 Revised keywords

This section includes all keywords used for the new round of searches. They are the result of a few iterations as described above during which small adjustments were made. The following sets of keywords are described:

- Keywords for fields supporting smart cities (Set A).
- Additional ICT keywords (to complement Set A).
- Keywords for smart city application areas (Set B).
- Keywords for smart city topics (Set C).
- Keywords for city organizational terms (Set D).
- Keywords for smart city objectives (Set E).
- Keywords for project management and software management (Set F).

Any changes (compared to the keywords used in Section 5) are marked as follows: additions to existing lists are printed in bold face, whereas any keywords removed from a list are marked with a strike through.

8.1.1 Updated keywords for fields supporting smart cities (Set A)

No changes were made to set Set A (fields supporting smart cities), but the full list is repeated here for completeness:

- 29.120 Electrical accessories
- 29.130 Switchgear and controlgear
- 29.240 Power transmission and distribution networks
- 31.120 Electronic display devices
- 31.220 Electromechanical components for electronic and telecommunications equipment
- 33.020 Telecommunications in general (including infrastructure)
- 33.030 Telecommunication services. Applications (including supplementary services, service aspects and associated legal tracability aspects)

- 33.040 Telecommunication systems (including network (system) aspects)
- 33.070 Mobile services
- 33.120 Components and accessories for telecommunications equipment
- 33.200 Telecontrol. Telemetering
- 35.020 Information technology (IT) in general
- 35.080 Software
- 35.110 Networking
- 35.200 Interface and interconnection equipment
- 35.240 Applications of information technology

8.1.2 Updated additional ICT keywords (to complement Set A)

No changes were made to the list of additional ICT keywords used to complement Set A, but the full list is repeated here for completeness:

- Interoperab*
- Interchang*
- Information
- Data
- Interface
- Smart
- Intelligent
- Communicat*
- Exchange*
- Transfer*
- Application*
- Automat*
- Messag*
- eSafety
- Protocol*
- Real-time
- Realtime
- Contactless
- OpenADR
- Cyber*

8.1.3 Updated keywords for smart city application areas (Set B)

Following the stakeholder consultation and further analysis of the results of the initial searches, two new fields have been added to the list of smart city application areas, namely 11.180 (Aids for disabled or handicapped persons) and 91.010 (Construction industry). The complete list is as follows:

- 03.080 Services
- 03.220 Transport
- 11.020 Medical sciences and health care facilities in general
- **11.180 Aids for disabled or handicapped persons**
- 13.020 Environmental protection
- 13.030 Wastes
- 13.040 Air quality
- 13.060 Water quality
- 13.200 Accident and disaster control
- 13.320 Alarm and warning systems
- 27.010 Energy and heat transfer engineering in general
- 27.080 Heat pumps
- 27.160 Solar energy engineering
- 43.020 Road vehicles in general
- 43.040 Road vehicle systems
- 43.060.50 Electrical and electronic equipment. Control systems
- 43.080 Commercial vehicles
- 43.100 Passenger cars. Caravans and light trailers
- 43.120 Electric road vehicles
- 43.160 Special purpose vehicles
- 45.020 Railway engineering in general
- 45.040 Materials and components for railway engineering
- 45.080 Rails and railway components
- 55.180 Freight distribution of goods
- 55.230 Distribution and vending machines
- **91.010 Construction industry**
- 91.020 Physical planning. Town planning
- 91.040 Buildings
- 91.140 Installations in buildings
- 91.160 Lighting
- 91.190 Building accessories
- 93.010 Civil engineering in general
- 93.080 Road engineering

- 93.100 Construction of railways
- 93.120 Construction of airports
- 93.140 Construction of waterways, ports and dykes
- 97.020 Home economics in general
- 97.030 Domestic electrical appliances in general
- 97.040 Kitchen equipment
- 97.060 Laundry appliances
- 97.080 Cleaning appliances
- 97.100 Domestic, commercial and industrial heating appliances
- 97.120 Automatic controls for household use
- 97.130 Shop fittings
- 97.180 Miscellaneous domestic and commercial equipment
- 97.200 Equipment for entertainment

8.1.4 Keywords for smart city topics (Set C)

In the first stage, a number of topics were identified which were not fully covered by the ICS keywords. The updated list of topics in Set C is as follows:

- Smart grid*
- Smart sensor*
- Smart meter*
- Assisted living
- Smart cards (Card Operating System)
- Biometric*
- Secure industrial control systems (ICs)
- Personal identity verification
- ~~Open data~~
- Cyber security
- Machine readable travel documents (MRTD)
- Social media
- Domotic*
- Ergonomics
- ~~Government~~
- Governance
- ~~Dashboard~~
- Displays

Items removed have instead been added to city organizational terms or smart city objectives Set D.

8.1.5 Keywords for city organizational terms (Set D)

A new set of keywords is created to represent the organizational structure and decision-making in cities. These keywords can help narrow down searches which are relevant for the different stakeholders and the urban setting. The list, however, does not only contain actors but also terms related to the decision-making and funding of large projects and investments.

- Government*
- Governance
- City
- Urban
- Functional urban area
- Metropolitan area
- Urban agglomeration
- Mayor
- City leader
- Council
- Local authority
- District
- Representatives
- Community
- Citizen
- Municipality
- Decision maker
- Leadership
- Coordination
- Supplier
- Vendor
- Procurement
- Investment
- Fund rais*
- Public-private partnership
- City service
- City infrastructure

Note that this list may need to be updated to fully cover international terms for the same concepts as they may not translate easily or accurately. In particular the way local neighbourhoods and areas are organized might vary between countries and different terms would be used when filing standards originating in those places.

8.1.6 Keywords for smart city objectives (Set E)

Based on smart city case studies [1] that have described current smart city initiatives around the world, a number of common objectives given as motivation for these projects can be compiled. The following keywords are derived from them:

- Sustainab*
- Inclusiv*
- Transparen*
- Collaboration
- Environment*
- Accountability
- Economic development
- Physical development
- Analytics
- Digital literacy
- Efficiency
- e-services
- e-government
- e-learning
- Open data
- Smart
- Job creation
- Citizen participation
- Community engagement
- Individualized
- Reliable
- Social cohesion
- Self-sufficien*
- Knowledge-based

Because there is risk that many of these keywords are too broad (e.g. transparency could also be literal rather than as a metaphor for visibility and openness in decision-making) a few test searches were required to make clear which keywords help obtain valuable results and which add to the noise. Using only a subset of these terms which are more clearly defined and linked to the domain of smart cities was considered, but a comparison revealed that with the above list still a manageable number of results was achieved. At first glance, the results appeared promising so it was decided to keep the full list.

8.1.7 Keywords for project management and software management (Set F)

The following keywords should be considered based on standards suggested during the stakeholder analysis:

- Enterprise architecture
- Business architecture
- Application architecture

- Data architecture
- Information architecture
- Concept of operations
- Requirements specification
- Project management
- Software acquisition
- Software life-cycle

However, it should be determined how applicable they are and how to transform this list in higher level concepts which are still applicable. Furthermore, the question is what additional sets should be used to ensure results are at the correct level of abstraction (e.g. results are only applicable if they deal with large multi-disciplinary projects at the city level).

8.2 Queries performed

Based on these sets, the following queries can now be performed:

1. (fields supporting smart cities (Set A) OR additional ICT keywords) AND Smart city application areas (Set B)

   Rationale: This query examines standards which are tagged with a field for a smart city supporting domain or ICT keyword (e.g. sensors or 'smart') as well as an application domain (e.g. transport or healthcare). The results should provide standards on how the supporting fields can be used in the various areas, with a focus on integration and interfaces.

2. Smart city topics (Set C)

   Rationale: This query looks at specific topics which may be relevant to the smart city (e.g. 'smart grid') using keywords which are not directly linked to ICS classifications. Standards returned will be directly applicable in those areas, but may also prove useful for other related projects.

3. City organizational terms (Set D) AND Smart city objectives (Set E) AND Smart city application areas (Set B)

   Rationale: This query explores, for all smart city application domains, standards which are related to cities or their organization and decision-making processes as well as objectives of smart cities. Results give support for strategic issues as well as implementation.

4. City organizational terms (Set D) AND Project Management keywords (Set F) AND Smart city application areas (Set B)

   Rationale: This query aims to find standards about project management which are relevant to stakeholders and decision-makers in the city for the application areas considered here.

5. ICT keywords AND City organizational terms (Set D) AND Smart city objectives (Set E)

   Rationale: Combining the specific ICT keywords with either organizational terms or objectives can bring forward standards where issues such as information exchange, automation and control and real-time are applicable to cities or any objectives for smart cities.

6. Exploratory queries: ('03.080 Services' OR '13.020 Environmental Protection') AND Smart city application areas (Set B).

   Rationale: This search is an exploratory query, aimed at finding out if a crossing of two categories which were already in Set B with the rest of Set B provides any additional relevant results. The services category could result in standards about the organization of various services in any of the application domains, and the environmental protection to address issues linked to the sustainability objective.

7. Exploratory queries: ('03.060 Finances. Banking. Monetary systems. Insurance OR 03.100 Company organization and management OR 03.120 Quality) AND (City organizational terms (Set D) AND Smart city objectives (Set E))

   Rationale: Another exploratory query looks at a number of groups in the ICS field 03 SERVICES. COMPANY ORGANIZATION, MANAGEMENT AND QUALITY. ADMINISTRATION. TRANSPORT. SOCIOLOGY and tries to identify whether they contain relevant standards in addition to the project management set (Set F). Combining them with the city organizational and smart city objective keywords helps narrow down the results to those relevant to the stakeholders in a city who may need to manage or fund smart city projects with a range of objectives in mind.

The first two queries were already part of the initial searches and will now be updated based on the minor revisions to the keywords, while the next three rounds are new aiming at finding process and strategic standards. It must be noted that the results of queries 1 and 2 are not necessarily purely technical standards and those of the other queries not necessarily non-technical either.

The results of queries 1, 2, 3 and 4 can possibly be merged under each of the keywords from Set B. Set B, after all, is used to focus the results to the application domains identified so standards which are not tagged with one of those domains are not likely to be relevant. The 5th query replaces earlier searches for ICT keywords AND (Ergonomics, Government OR Governance) as performed during the initial searches. Two exploratory queries provide input for the design of yet further searches. Their results are not finetuned yet, but are meant to indicate if additional searches in this direction may be helpful and to learn how they can be best phrased to lead to as few false positives (i.e. standards which come up with the keyword combination but have to be manually filtered out since they appear not to be important) while still finding the appropriate results we are interested in.

Just like during the first stage of searches, if duplicates are found under more than one query these are not eliminated but preserved; removal of duplicates was only done for each individual query.

8.3 Results

In this section the results of these queries are summarized. First, the two queries which were already part of Stage 1 are updated. Table 3 shows the additional results obtained in addition to those already listed in Table 1. Since no keywords were added to Smart city topics (Set C) no additional results can be reported in addition to those already in Table 2.

Table 3 — Updated results of keywords searches Set B + (Set A or additional ICT keywords) in addition to Table 1

Topic (Set B)	Quantity	Example standard
11.180 Aids for disabled	32	Traveller information for visually impaired people
91.010 Construction industry	23	European eConstruction ontology

The results of the third query are shown in Table 4. This is the combination of the city organizational terms (Set D), smart city objectives (Set E) and the smart city application areas (Set B).

Table 4 — Results of keywords searches, City organizational terms (Set D) AND Smart city objectives (Set E) AND Smart city application areas (Set B)

Topic (Set B)	Quantity	Example standard
03.080 Services	16	Energy services provided under guaranteed energy savings contracts
03.220 Transport	19	Implementing quality in mobility management in small and medium sized cities
11.020 Medical	0	–
11.180 Aids for disabled[12]	14	Accessibility in building and urbanism – Design general criteria
13.020 Environment	52	Smart community infrastructures
13.030 Wastes	1	Product information between producers and recyclers
13.040 Air quality	0	–

12 No results were found using AND, but since some results in this area were expected an alternative query with OR was performed

Topic (Set B)	Quantity	Example standard
13.060 Water quality	0	–
13.200 Accident	9	Standard test method for evaluating emergency response robot
13.320 Alarm	1	Closed circuit television (CCTV). Management and operation
27.010 Energy	0	–
27.080 Heat pumps	0	–
27.160 Solar	2	Thermal solar systems performance test
43.020 Road vehicles	2	Road vehicles – Open test sequence eXchange format
43.040 Road vehicle systems	7	Location referencing message specification
43.060.50 Control systems	0	–
43.080 Commercial vehicles	0	–
43.100 Passenger cars	0	–
43.120 Electric vehicles	0	–
43.160 Special purpose	0	–
45.020 Railway	7	Railway applications – The specification and demonstration of reliability, availability, maintainability and safety
45.040 Railway materials	0	–
45.080 Railway components	0	–
55.180 Freight distribution	2	Freight containers – Radio frequency identification
55.230 Vending machines	0	–
91.010 Construction industry	3	Building information models – Information delivery manual
91.020 Physical planning	1	Inclusive urban design – A guide to creating accessible public spaces
91.040 Buildings	15	Sustainability of construction works – Assessment of buildings
91.140 Installation in buildings	18	Facility management – Lifecycle-cost-based tender
91.160 Lighting	0	–
91.190 Building accessories	0	–
93.010 Civil engineering	1	Early public participation in industrial and infrastructure projects
93.080 Road engineering	1	Traffic controller assemblies
93.100 Railways	0	–
93.120 Airports	0	–
93.140 Waterways	0	–
97.020 Home economics	0	–
97.030 Electrical appliances	0	–
97.040 Kitchen	0	–
97.060 Laundry	0	–
97.080 Cleaning	0	–
97.100 Heating appliances	0	–
97.120 Automatic controls	7	Open data communication in building automation, controls and building management
97.130 Shop fittings	0	–
97.180 Misc equipment	0	–
97.200 Entertainment	0	–

The fourth query returned very few results, with most combinations having no hits. Table 5 shows only those fields from Set B for which standards could indeed be found. It should be noted that all these standards already came up in the previous query and can be found in Table 4.

Table 5 — Results of keywords searches City organizational terms (Set D) AND Project Management keywords (Set F) AND Smart city application areas (Set B). All fields not listed are empty.

Topic (Set B)	Quantity	Example standard
45.020 Railway	3	Railway applications – The specification and demonstration of reliability, availability, maintainability and safety
91.010 Construction industry	1	Building information models – Information delivery manual

The fifth query, ICT keywords AND (City organizational terms (Set D) AND Smart city objectives (Set E)), produced around 500 standards on a wide range of topics. Some of these are highlighted below (in alphabetical order):

- A model for the classification of quality approaches in eLearning.
- Biometrics for public sector applications.
- Business interoperability interfaces for public procurement.
- Characteristic heating-energy, electrical-energy and water consumption values.
- Collaboration between the supplies departments and the commercial departments of the various railways for orders.
- Communication networks and systems for power utility automation.
- Discovery of and access to e-Government resources.
- Energy management system application program interface.
- e-Tendering process.
- EU e-Government metadata framework.
- Geographic information – Geography markup language (GML).
- Information technology – Technical introduction to e-Business modelling.
- Management tools – Information management.
- Multi-application multi-issuer citizen card scheme standardization.
- Open data communication in building automation, controls and building management.
- Postal services – Open standard interface – Address data file format.
- Substation intelligent electronic devices (IEDs) cyber security capabilities.
- Systems and software engineering – Life cycle processes – Project management.

The complete lists produced from these searches are available at www.bsigroup.com/smartcitymapping. The results of the exploratory queries will be discussed in Section 10 and suggestions for follow up searches will be made.

8.4 Analysis

The new results have again provided a fairly large number of standards. Small updates in Set B have lead to further completing the results produced earlier, and the additional queries show there are also standards available with a less technical focus. Where during the first phase all keyword combinations have resulted in standards which appear to be relevant, that was not the case in the second phase. The keyword combinations were more restrictive with additional AND operators, so that in itself is a reason there are fewer hits. Furthermore, the emphasis of standardization efforts has been mostly in the technical domains so fewer results were expected already. The fifth query, combining ICT keywords with city organizational terms and smart city objectives, led to a large number (of unstructured) findings, many of which seem useful, but again a large number of them are technical (and were in fact already found in earlier queries too).

Still, it can be concluded that the additional queries were successful in that they brought up highly applicable standards that were not discovered in the first phase. Furthermore, if indeed the focus of standards developing organizations might shift to more process and strategic domains (since stakeholders have said that they are looking for guidance there) then with these queries they will be discovered in due time. A number of standards which are currently under development, such as those prepared by ISO/TC 268 or BSI's PAS 180 (smart cities vocabulary) should also come up if these queries are repeated in the near future: the titles, keywords as well as planned ICS classification(s) match those provided here.

As said above, duplicates between queries have not been removed to make clear how the results were obtained, but this does slightly obscure the overview picture. Still, it appears the general impression on which domains have received most attention has not really changed: (intelligent) transport systems, environmental topics and building automating have again large numbers of standards. Additional topics that came up now include the Open System Interconnection, business interoperability, sustainable procurement and investment, e-Government, electronic fee collection and Geographical Information Systems, for example. The new searches have clearly broadened the scope of the results.

In particular, the combination of city organizational keywords, smart city objectives and field 13.020 (Environment) provided some key standards which were missing previously, including:

- Sustainable development and resilience of communities. Indicators for city services and quality of life.
- Smart community infrastructures. Review of existing activities relevant to metrics.
- Guidance for community sustainable development.

In the next section an attempt is made to further classify the key findings by presenting a selection of the found standards in more detail.

9. Overview of smart city standards

Taking the results of the two phases together, various lists of standards related to smart cities, smart city applications, supporting infrastructures, objectives and organization were found. Some are very specific and only related to a particular device in a specific field. Such standards are important mostly for people working exactly in that area, and while it provides context for other applications that may link with this system, it will not be useful for actors at different levels or those working in other areas. In this section a selection of those standards that cross domains and decision-making levels is presented. It is expected that these standards will have a direct impact on the design and implementation of smart city projects. This does not mean others are not at all relevant, but just that they can be hidden at the 'smart city level'.

The selection is produced by going through every list created during the study and picking those standards which are specifically about integrating two or more domains, about the decision-making processes and/or high level objectives. Just like during the filtering step of the results of the individual queries, this is a manual task which is difficult to standardize and formalize so the outcomes are a personal interpretation. The aim is to provide a starting point for the more detailed analysis of the available standards. This selection could be discussed and possibly repeated by a wider group to further validate and strengthen the overview.

In the following sections a selection of nearly 100 smart city standards is presented at three levels: technical, process and strategic standards. The technical standards are mostly about 'what' needs to be done in terms of implementation and/or operation. Process standards deal more with the 'how' and are related to actions or steps to be taken. Finally, strategic standards address 'why' and provide guidance for stakeholders in planning and management.

For each standard the document identifier is given as well as the full title of the standard. Also, the issuing body is provided, or, if the standard listed is a local adoption of an international standard, the international reference (if provided in the Perinorm database).

9.1 Technical standards

Table 6 shows a selection of technical standards which were found during the searches in this study.

Table 6 — Selection of smart city standards – Technical

Document ID	Title	SDO
ANSI/ASQ E 4	Specifications and guidelines for quality systems for environmental data collection and environmental technology programs	ANSI
BS EN 14908-5:2009	Open data communication in building automation, controls and building management implementation guideline – Control network protocol – Implementation	CEN
BS EN 60730-1:1992	Specification for automatic electrical controls for household and similar use – General requirements	CEN
BS ISO 14813-1:2007	Intelligent transport systems – Reference model architecture(s) for the ITS sector – ITS service domains, service groups and services	ISO
CR 205-006:1996 en	Home and building electronics system (HBES) – Technical report 6: Protocol and data integrity and interfaces	NEN
CSN ISO/IEC TR 15067-3	Information technology – Home electronic system (HES) application model – Part 3: Model of an energy management system for HES	ISO/IEC
CWA 14947:2004 en	European eConstruction architecture (EeA)	CEN
CWA 15264-3:2005	User requirements for a European interoperable eID system within a smart card infrastructure	CEN
CWA 16073-0:2010 en	Business interoperability interfaces for public procurement in Europe – Part 0: Introduction	CEN
DD CEN/TS 13149-6:2005	Public transport – Road vehicle scheduling and control systems – CAN message content	CEN
DIN SPEC 33440	Ergonomic design of user-interfaces and products for smart grid and electromobility	DIN

Document ID	Title	SDO
DS/EN 61970-1	Energy management system application program interface (EMS-API) – Part 1: Guidelines and general requirements	IEC
EIA TSB 4940	Smart device communications – Security aspects	EIA
EN 60730-1	Automatic electrical controls for household and similar use – Part 1: General requirements (IEC 60730-1:2010, modified)	CENELEC
ETSI GS OSG 001 V 1.1.1	Open smart grid protocol (OSGP)	ETSI
ETSI TR 102935 V 2.1.1	Machine-to-Machine communications (M2M) – Applicability of M2M architecture to smart grid networks – Impact of smart grids on M2M platform	ETSI
GOST R 55060	Automatized control systems of buildings and structures. Terms and definitions	GOST R
GOST R ISO 15007-1	Ergonomic of vehicles – Measurement of driver visual behaviour with respect to transport information and control systems – Part 1: Definitions and parameters	GOST R
IEC 62290-1	Railway applications – Urban guided transport management and command/control systems Part 1: System principles and fundamental concepts	IEC
IEEE 1851	IEEE standard for design criteria of integrated sensor-based test applications for household appliances	IEEE
ISO 15118-1	Road vehicles – Vehicle to grid communication interface – Part 1: General information and use-case definition	ISO
ISO 16354	Guidelines for knowledge libraries and object libraries	ISO
ISO 16484-5	Building automation and control systems – Part 5: Data communication protocol	ISO
ISO/PAS 22720	Association for standardization of automation and measuring systems open data services 5.0	ISO
ISO/TS 24533	Intelligent transport systems – Electronic information exchange to facilitate the movement of freight and its intermodal transfer – Road transport information exchange methodology	ISO
ITU-T X.207	Information technology – Open systems interconnection – Application layer structure	ITU
NEMA SG-AMI 1	Requirements for smart meter upgradeability	NEMA
NEN 7512:2005 nl	Health informatics – Information security in the healthcare sector – Basis for trust for exchange of data	NEN
NEN-EN-ISO 24534-3:2013	Intelligent transport systems – Automatic vehicle and equipment identification – Electronic registration identification (ERI) for vehicles – Part 3: Vehicle data	CEN
NPR-CEN/TR 16427:2013 en	Intelligent transport systems – Public transport – Traveller information for visually impaired people (TI-VIP)	CEN
OEVE B/EN 60555-1/1987	Disturbances in supply systems caused by household appliances and similar electrical equipment – Part 1: Definitions	OVE
PAS 1018	Essential structure for the description of services in the procurement stage	DIN
PAS 1036	Solution catalog with glossary for e-Government	DIN
PAS 1067 GAEB DA XML	Organization of the information exchange regarding the execution of construction work	DIN
PAS 1090	Demands on information systems for collecting, communicating and serving of relevant service information within the technical customer service	DIN
PAS 555:2013	Cyber security risk – Governance and management – Specification	BSI
SS-ISO 15784-1:2008	Intellligent transport systems (ITS) – Data exchange involving roadside modules communication – Part 1: General principles and documentation framework of application profiles (ISO 15784-1:2008, IDT)	ISO
UTE C15-900U*UTE C15-900	Coexistence between communication and power networks – Implementation of communication networks	UTE
VDI 3805 Blatt 1	Product data exchange in the building services – Fundamentals	VDI
VDI 3807 Blatt 2	Characteristic values of energy consumption in buildings – Characteristic heating-energy, electrical-energy and water consumption values	VDI
VDI 3814 Blatt 7	Building automation and control systems (BACS) – Design of user interfaces	VDI
VDI 4201 Blatt 1	Performance criteria on automated measuring and electronic data evaluation systems for monitoring emissions – Digital interface – General requirements	VDI/DIN
VDI 6027 Blatt 2	Requirements for the data exchange of CAD systems – Building service equipment	VDI

9.2 Process standards

A selection of process standards can be found in Table 7.

Table 7 — Selection of smart city standards – Process

Document ID	Title	SDO
BS ISO 20121	Event sustainability management systems – Requirements with guidance for use	ISO
ASTM E 1121	Standard practice for measuring payback for investments in buildings and building systems	ASTM
BIP 2207	Building information management – A standard framework and guide to BS 1192	BSI
BS 8587:2012	Guide to facility information management	BSI
BS 8903:2010	Principles and framework for procuring sustainably – Guide	BSI
CAN/CSA-ISO/TS 14048:03 (R2012)	Environmental management – Life cycle assessment – Data documentation format	CSA
CWA 15666:2007 en	Business requirement specification – Cross industry e-Tendering process	CEN
CWA 15971-1	Discovery of and access to eGovernment resources – Part 1: Introduction and overview	CEN
CWA 16649:2013 en	Managing emerging technology-related risks	CEN
CWA 50487:2005 en	SmartHouse Code of Practice	CEN
DS/ISO/IEC 18012-2	Information technology – Home electronic system – Guidelines for product interoperability – Part 2: Taxonomy and application interoperability model	ISO/IEC
FD P01-066*FD CEN/TR 15941	Sustainability of construction works – Environmental product declarations – Methodology for selection and use of generic data.	AFNOR
ISO 16484-1	Building automation and control systems (BACS) – Part 1: Project specification and implementation	ISO
ISO/IEC 17998	Information technology – SOA governance framework	ISO/IEC
ISO/IEC TR 29138-1	Information technology – Accessibility considerations for people with disabilities – Part 1: User needs summary	ISO
ITU-T L.1410	Methodology for the assessment of the environmental impact of information and communication technology goods, networks and services	ITU
NEN-ISO 29481-2:2012 en	Building information models – Information delivery manual – Part 2: Interaction framework	ISO
NEN-ISO/IEC 16326:2010 en	Systems and software engineering – Life cycle processes – Project management	ISO/IEC
NF P01-061-1*NF EN 15643-1	Sustainability of construction works – Sustainability assessment of buildings – Part 1: General framework.	AFNOR
NPR-ISO/TR 12859:2009 en	Intelligent transport systems – System architecture – Privacy aspects in ITS standards and systems	ISO/TR
RAL-UZ 170	Basic criteria for award of the environmental label – Energy services provided under guaranteed energy savings contracts	RAL Güte
SS-ISO/IEC 27005:2013	Information technology – Security techniques – Information security risk management	ISO/IEC
VDI 3814 Blatt 5	Building automation and control system (BACS) – Advices for system integration	VDI
VDI 4466 Blatt 1	Automatic parking systems – Basic principles	VDI
VDI 7000	Early public participation in industrial and infrastructure projects	VDI
VDI/GEFMA 3814 Blatt 3.1	Building automation and control systems (BACS) – Guidance for technical building management – Planning, operation, and maintenance – Interface to facility management	GEFMA

9.3 Strategic standards

Table 8 shows a number of strategic standards which were found in this study.

Table 8 — Selection of smart city standards – Strategic

Document ID	Title	SDO
BS ISO 37120	Sustainable development and resilience of communities – Indicators for city services and quality of life	ISO
BS ISO/TR 37150	Smart community infrastructures – Review of existing activities relevant to metrics	ISO
ABNT NBR 14022	Accessibility in vehicles of urban characteristics for public transport of passengers	ABNT
BIP 2228:2013	Inclusive urban design – A guide to creating accessible public spaces	BSI
BS 7000-6:2005	Design management systems – Managing inclusive design – Guide	BSI
BS 8904:2011	Guidance for community sustainable development	BSI
BS EN 15331:2011	Criteria for design, management and control of maintenance services for buildings	EN
CLC/FprTR 50608	Smart grid projects in Europe	CENELEC
CWA 15245	EU e-Government metadata framework	CEN
CWA 16030:2009	Code of practice for implementing quality in mobility management in small and medium sized cities	CEN
CWA 16267:2011	Guidelines for sustainable development of historic and cultural cities – Qualicities	CEN
DIN SPEC 91280	Ambient assisted living (AAL) – Classification of ambient assistant living services in the home environment and immediate vicinity of the home	DIN
GOST R 54198	Resources saving – Industrial production – Guidance on the application of the best available technologies for increasing the energy efficiency	GOST R
PAS 181:2014	Smart city framework – Guide to establishing strategies for smart cities and communities	BSI
UNI 10951:2001	Systems of information for the maintenance management of buildings – Guidelines	UNI
VDI 7001	Communication and public participation in planning and building of infrastructure projects – Standards for work stages of engineers	VDI
X30-025*BP X30-025	Good practices for the transparency of the information about the social conditions of production and product distribution	AFNOR
Z762-95 (R2011)	Design for the environment (DFE)	CSA

9.4 Active standards bodies

One of the aims of this study was to create an overview of which standards bodies are involved in this domain. Unfortunately it is difficult to do due to indiscriminate elimination of duplicate standards, which means that standards adopted by other organizations may have disappeared while only one of the adopted organizations is still included. Still, in most cases the committee or SDO which developed the standard is included in the results from the database searches so it can still be extracted. Even if the document identification points at a national standards body, the origin should be listed separately.

Standards for smart cities are developed around the world, but in the selection of standards presented in Section 9 it seems there is a strong contribution from Europe in particular. For the technical standards, ISO and IEC are especially active in a wide range of topics, in addition to standard bodies from Europe (national standards bodies including DIN, or NEN or institutes such as CEN, CENELEC or ETSI) while American standards are represented by ANSI and IEEE. A significant number of standards come from Russia (GOST R).

Moving onto process standards, the influence of ISO and IEC is less visible and it is mostly European standards bodies who produce standards here. Again this includes CEN and CENELEC, but BSI, NEN and in particular VDI seem very active. Similarly, the strategic standards are less dominated by ISO. At this level BSI and CEN are the biggest contributors to smart city standards. Having said that, ISO is currently developing standards which would fit into those categories as well. See [11] for an overview of ISO's activities in the domain.

It should also be noted that the Perinorm database does not cover all countries, so additional searches are required to better understand which organizations are actively developing smart city standards. More details are available at www.bsigroup.com/smartcitymapping, including a report on the activities of private standards bodies and a document detailing the scope of Perinorm.

10. Recommendations and future work

The work presented in this report is intended as a starting point for further analysis of existing standards and making them available to stakeholders. In this section a number of recommendations for next steps are given.

10.1 Exploratory queries

The combination of 03.080 (Services) and the rest of Set B leads to a number of somewhat relevant standards, but it appears that any key results brought up would have already been present in the final outcomes. Examples of topics that have come up with this search include:

- services which should be available in stations handling international traffic;
- concepts for the development of business models for provision of prevention services in the health sector;
- energy management – energy audits – general requirements for the energy audit service;
- criteria for design, management and control of maintenance services for buildings; and
- a small number of results on drinking water and ambient assisted living.

There is also some clear overlap with results from other searches.

Likewise, 13.020 (Environmental protection) crossed with the other keywords in Set B brings up a small number of new topics, but again nothing major. A few examples are shown here:

- Environmental management system on composting plants.
- Methods for evaluation of waste treatment processes.
- Energy efficiency benchmarking methodology.
- Framework for managing sustainable development in business districts.

Additionally there are some standards for environmental labels in various fields and the topic of sustainability of construction works is one of the most prominent in this set.

The category on finances, banking and monetary systems has no results when searched in conjunction with city organizational and smart city objective keywords, but using the OR operator instead produces a relatively small number of hits which are mostly relevant. The most interesting ones, for example, on e-Government, were already included in other searches. The searches with company organization and management look promising, with topics such as risk management, public procurement and social responsibility but again key results were already discovered using the other keywords combinations. Finally, doing these same searches with 'quality' as a category brings a small number of dependability management standards and some on customer satisfaction. However, the ones that seem the most relevant were already extracted with other keyword combinations.

The full results are available at www.bsigroup.com/smartcitymapping. For further studies it may be worth looking at ways to integrate these topics more into the general queries, perhaps by extracting some additional keywords from the new standards that were brought up in the search results.

10.2 Replication

The intention of this report is to enable easy replication of the current findings. The methodology, lists of keywords and queries used are described in detail to allow others to repeat the work. This makes it possible to monitor the changes in this area and capture any newly developed publications. Keeping track of these developments is essential not only to better understand opportunities for drafting new standards, but also to tell the relevant stakeholders about new guidance available to them. The second stage of this work, where the emphasis should be on making the lists that came out of the first stage easily accessible to any stakeholder, heavily relies on the results being up-to-date. By repeating the searches and listing the updates, the results available to the stakeholders can be refreshed as well.

10.3 Filtering results

Filtering the outcomes of the database queries to remove any results which are not useful was a labour-intensive task. It is not always straightforward to decide if a standard should be included or not, in particular when only the title and an abstract is available. The results presented here, in particular the number of standards given in the tables, should be considered as an upper limit for the given keywords. It will require a team of domain experts to validate the filtering and make a better informed decision on the selection.

10.4 The use of ICS codes

Reflection of the results found using the ICS classification suggests that this approach has been quite successful in producing quality results that required relatively little filtering afterwards. The main advantage is that the searches do not rely on matching free text keywords (which may be open to interpretation). The classification is well-defined and widely accepted, and the committees developing the standards can choose which fields they think are the most appropriate. As this is done by humans rather than by blindly matching keywords (which is what computers would do) the quality of the tags is very high.

However, it is often hard to find the right classification for combinations of sectors, or choose the right combination of application domain and supporting technologies. Additional queries can be run to specifically look for occurrences where standards were tagged by for example two infrastructure sectors or a combination of services and infrastructure. Furthermore, an increase in the number of standards in this domain could flag up the need for new categories for smart city related standards. It would be desirable to make it easier to classify standards that focus on integration and interoperability outside of the current silos.

10.5 Categorization of standards for stakeholders

In the next stage, the standards found in this study can be made more easily accessible to various stakeholders in a structured way. It should be easy for somebody to retrieve those and only those standards which will aid in the task ahead. If the results shown include too many irrelevant standards there is a risk the useful ones will be overlooked or too much time invested in filtering out those which are not beneficial. Instead of making all standards visible, only those which are relevant at the time should be highlighted, depending on what the user wants to see. Clearly this is not an easy task, especially with the wide range of disciplines, levels of decision-making, types of organization, etc, in the smart city domain. These combinations can also change each time. A more advanced way to structure the results of this study is therefore required, going beyond the lists sorted just by topic (i.e. the members of the set of smart city application areas or the smart city topics) or the level of guidance (what, how, or why).

In the overview of smart city standards presented in this report it seems the three layer classification in technical, process and strategic is sufficient without creating lists which are too long. Each level is likely to be of interest to a different actor role (e.g. management vs implementation) without having to make this specific. Especially when used in combination with an application domain or other classifiers

this would produce a manageable number for stakeholders to process. Still, more detail is required especially when the domain-specific standards without clear interaction with the wider context, including those identified during the searches, are added as well.

As a way forward, each standard should be tagged with several relevant terms to allow it to be found depending on the aims of the person searching, as the keywords (in title, abstract and/or descriptors) and classifications of each standard are not sufficient for searching beyond the domain. Extra tags which are manually added to the standard can be used alongside the other keywords to provide more structure.

For the topic of the standard, the ICS codes could be sufficient as they already provide a clear structure of different fields. However, it might be beneficial to add a classification which groups a number of fields together. In other cases it might help to add lower levels which provide more detail. For example, the Service field has a group for transport, but there are also separate fields for transport and transport infrastructures. Somebody looking for standards for planning an interface with an intelligent transport system might be interested in standards in all those categories, without wanting to go through all fields separately. Furthermore, when the topic is a new smart parking project, an additional subject classifier could filter out any which are not related to parking even if they are still in the same transport domain. It requires domain experts to add this knowledge, so standards can be retrieved without relying just on the computer matching exact keywords with how they are used in the standard definition.

To classify the level of interaction between systems (physical and/or social) some structure similar to the ISO/OSI layers is worth exploring, although it may provide too much detail to justify the extra effort required to decide what the relevant levels are for each standard. This also depends on the number of standards included; as the number of standards grows it will be more likely that more subdivisions in levels can be identified. Again, domain experts will need to look into this as they will have better understanding on what a relevant division is. This may not need to be the same in each area.

Another classification that could be useful to help stakeholders find those standards relevant to them is scale. For example, a spatial scale ranging from device, building, neighbourhood, city, metro area and country. It does not necessarily have to be a very detailed distinction but something that is intuitive for the stakeholders. A spatial scale allows people to roughly specify what they are interested in. For example, a mayor might only want to see standards that operate at a neighbourhood and city level, while somebody responsible for improving the energy efficiency of an office block would want to see building and device level standards. Similarly a temporal scale could be used (e.g. second/minute, hour, day, month, year, decade) to filter out those standards that are useful. To use the same example, the mayor and his advisors might want to concentrate on standards that do not relate to the temporal scale of minutes and hours while the person planning the retrofit of an office block might need everything from the second-by-second operation of energy saving devices to the year-long effects and consequences. Adding domains or other additional classifiers in the search can help to further narrow this down.

One suggestion is that, like the smart grid project highlighted in the stakeholder consultation, use cases are applied to decide on the exact choice of classifications and their levels. A 3D model might indeed be a useful way to visualize this even though there are some limitations in particular when pointing out combinations of domains which are not displayed alongside one another on one of the axes. Furthermore, while the underlying database can be the same, the visualization used could be different for types of actors, using multiple models so a world-view they instantly recognize is available. This would make it easier to gain insights from the results.

In any case, it is hoped that the selection as well as the full lists of standards uncovered in this report will provide a solid foundation for the next phase and a useful starting point for engaging with domain experts and other stakeholders to determine the best way to represent and visualize them in a way that makes it easier for the relevant standards to be highlighted to an individual.

11. Conclusions

This report describes the findings of a study looking at relevant standards for smart cities, helping to highlight existing possibilities as well as identifying gaps and opportunities. The report can be summarized as follows:

- The aim of this study was to map existing standards relevant to smart cities based on a model of data and information flows in the city context.
- Existing models of smart cities are useful as a foundation, but lack a direct focus on information flows at the city level or are too vague to support the review in sufficient detail.
- A new model was proposed based on the analysis of previously published models covering a technical as well as a social view of smart city application areas.
- A keyword search of existing standards was performed following the ICS classification of standards. Queries were based on the cross-sections from the smart city model, linking application domains with smart city enabling and supporting fields.
- After an initial search it was concluded that several topics were not yet covered by the ICS keywords, so a number of additional ICT-related keywords were prepared, as well as a list of topics which in their own right could be relevant to search for.
- The results of this survey were presented by considering the number of standards found as well as a typical example of an existing standard. The full results are made available at www.bsigroup.com/smartcitymapping.
- Transport, installations in buildings and the environment were the topics with the largest body of standards found.
- In general most standards relate to infrastructure based sectors and the built environment, supported by ICT and smart city related technology with only little specific work found in the service-based sectors.
- The feedback from the stakeholder consultation was mostly positive, with support for the methodology and the use of ICS keywords in particular as well as keen interest in the various smart city models presented and their inspiration for the proposed model. It was noted that strategic and process standards were still lacking in the results.
- The model and resulting keywords were updated to take into account smart city objectives as well as stakeholder descriptions with the aim to discover more higher level standards.
- New queries were run and analysed, confirming that new standards were uncovered.
- A selection of nearly one hundred standards were presented, for technical, process and strategic levels. This gives an overview of the type of standards which are available and can guide new smart city projects and initiatives.
- From the selected smart city standards, it can be seen which standards bodies are active in this domain. The technical standards are typically the domain of ISO and IEC, while process and strategic standards are mostly developed by the European national standards bodies and European organizations such as CEN.
- The next step is to take the resulting lists of smart city standards and to start thinking about ways to make those accessible to stakeholders in an intuitive and easy way. A number of recommendations are given for follow up work, including a suggestion for the categorization of standards so they can be made discoverable more easily.

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