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Smart cities — Guidance to establishing a decision-making framework for sharing data and information services

Villes intelligentes — Recommandations pour l'établissement d'un cadre décisionnel pour le partage des données et des services d'information

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0 Introduction

0.1 General

The term “smart city” denotes the effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens. A basic assumption in the design of a smart city is the ability of the physical and digital systems to be interoperable. This standard gives governance guidance for decision-makers on establishing a decision-making framework for sharing city data and creating interoperable information services.

Data has the ability to transform the city and its services, providing visibility on the services available, and supporting citizen interactions with those services. Improving the design and integration of city services can serve the public better and drive innovation and efficiencies.

This standard aims to support data sharing in cities and between cities, and the establishment of data sharing agreements, particularly where data is being shared by multiple organizations to transform the delivery of city services.

Missing data or misinterpretation of data can lead to the wrong actions being taken by city decision-makers. A decision-making framework for sharing data can help ensure that they have the best overall data ecosystem on which to base decisions.

Sharing data across a city requires more than the interoperability covered by the smart city concept model (SCCM) defined in ISO/IEC 30182, which focuses by necessity on the semantics of data in a city. Full data interoperability requires a

data framework to be created across the entire spectrum of data for a city: open, closed and shared data.

This standard builds on the integrated operating model defined in ISO/IEC 37106:2021 and assumes that the governance of a smart city programme and the overall management of the city’s data assets has been understood and agreed upon by city leaders and decision-makers from the organizations delivering city services.

The value of data sharing has yet to be explored by cities, as data is predominantly currently used for a specific purpose related to the public task, additionally data

is not viewed as an essential city asset which can be used to transform a city. Data can also provide the basis for new commercial models in smart cities.

This standard defines the data framework for sharing city data to enable discussions between the specialists who build and design the physical and digital services and the decision-makers using data to transform their city.

This standard is for use by decision-makers in smart cities from the public, private and third sectors. It is also of interest to any city organization wishing to share data.

It is expected that each city will create a decision-making framework based on this standard to address its own challenges and opportunities, taking into account the priorities and needs of their city. The creation of a data ecosystem based on the interoperability and data sharing principles in this standard could create data assets that are used to improve the quality of life for citizens and create sustainable commercial models to fund innovation.

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0.2 Relationship to other smart city standardization documents

0.2.1 ISO 37106

This standard has been built on the guidance in ISO 37106, *Sustainable cities and communities* – Guidance on establishing smart city operating models for sustainable communities . The particular components of a smart city framework which apply are:

a) [B2] Transforming the city's operating model with particular reference to the governance model developed and any vulnerabilities of both data and city services;

b) [B6] Establishing a common terminology and reference model; and

c) [B10] Identity and privacy management.

This standard is guidance to help with the implementation of these components of the smart city framework.

0.2.2 ISO/IEC 30182

The smart city concept model (SCCM) described in ISO/IEC 30182, *Smart city concept model – Guide to establishing a model for data interoperability* addresses the data interoperability issues that arise as a result of each sector and/or service in a city having its own model and terminology that it uses for data. This standard defines the data framework that addresses the other areas that affect interoperability, such as access rights, privacy, availability and formats. These other areas are also barriers to interoperability and portability which impact the design of the physical and digital services.

This standard addresses the barriers other than the semantics addressed in ISO/IEC 30182 , to enable data interoperability and portability, and the sharing of data and information services in a smart city.

The data framework identifies all elements which will be needed to deliver the four key types of insight when data and services are appropriately shared:

operational, critical, analytical and strategic insight. (See ISO/IEC 30182:2017, Clause 0).

0.3 Relationship to building information modelling (BIM) standards

The following documents are considered to be the foundational standardization documents to be used as part of a whole lifecycle approach to the built environment for BIM Level 2 in smart cities.

This standard assumes that the ISO 19650 series is used for all BIM Level 2 building and infrastructure assets in a smart city and that asset procuring organizations use them as part of their overall digital and smart strategies.

- ISO 19650-1, Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling – Part 1: Concepts and Principles;
- ISO 19650-2, Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling – Part 2: Delivery phase of the assets;
- ISO 19650-3, Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling – Part 3: Operational phase of the assets;

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- ISO 19650-4, Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling – Part 4: Information exchange;
- ISO 19650-5, Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling – Part 5: Security-minded approach to information management.

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1 Scope

This standard gives guidance on establishing a decision-making framework for sharing data and information services in smart cities.

It covers:

a) types of data in smart cities;

b) establishing a data sharing culture;

c) data value chain – roles and responsibilities;

d) purposes for data use;

e) assessing data states;

f) defining access rights for data; and

g) data formats/format of transportation.

This standard aims to support the sharing of data and information services within cities. For some cities there will also be a need to establish specific data sharing agreements, particularly where data is being shared by multiple organizations at once.

This standard supports a transparent approach to making decisions and creating specific data sharing agreements in order to fully realise the benefits and value of data and information services in a city.

Missing data or misinterpretation of data can lead to the wrong actions being taken by city decision-makers. A decision-making framework for sharing data can help ensure that they have the best overall data on which to base decisions.

This standard does not cover:

a) national security issues;

b) good practice for use of data by the citizen;

c) existing interoperability agreements between cities;

d) defining application programming interfaces (API) networks; or

e) any data sharing rules and regulations specific to a particular jurisdiction. It is assumed that a security-minded approach to data sharing is used by cities.

NOTE 1 Further details on the areas not covered in this standard, including information on relevant standards publications, are given in Annex A.

This standard is for use by decision-makers in smart cities from the public, private and third sectors. It is also of interest to any city organization wishing to share data.

2 Terms and definitions

For the purposes of this standard, the terms and definitions given in ISO 37100 and the following apply.

2.1 closed data

data which has been restricted for use

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2.2 data

recorded information

[SOURCE: ISO 22005:2007, **3.11**]

2.3 data framework

classification of data assets as either metadata, reference or thematic data

2.4 data spectrum

differentiation of data assets on the basis of whether they are considered closed, sharable or open

2.5 data value chain

intelligent use, management and reuse of data to deliver insight

2.6 derived data

data item used in analysis and/or tables derived from one or more source data items and/or categories

[SOURCE: ISO 20252:2012, **2.2**]

2.7 metadata

data that defines and describes other data [SOURCE: ISO 24531:2013, **4.32**]

2.8 open data

data that can be freely used, modified, and shared by anyone for any purpose

2.9 reference data

data that defines the set of permissible values to be used by other data fields

2.10 thematic data

patterns of data within the data framework that are deemed important to support the provision of city services and the four levels of insight in the city

3 Data Sharing

The SCCM detailed in ISO/IEC 30182 is a basis for understanding the semantic interoperability of data in a smart city. This governance standard assumes the city has utilized the concepts in the SCCM as the basic building block of data interoperability in their city. This use of the SCCM can enable the four levels of insight – operational, critical, analytical and strategic – to be achieved from the data.

However the use of the SCCM guidance alone does not address all the barriers to data sharing in the city. Other aspects of data also need to be understood to create an appropriate framework for data sharing in a smart city.

To achieve effective data sharing, seven key data sharing areas are deemed to be additional barriers and should be considered individually and collectively by the city:

a) types of data;

b) establishing a data sharing culture;

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c) data value chain;

d) purposes for data use;

e) assessing data states;

f) defining access rights for data; and

g) data formats/format of transportation.

This standard guides cities on these areas to address in order to establish a data framework to share data. The sharing models which are covered within the scope of this standard are:

a) public sector and public sector;

b) public sector and local business or community;

c) public sector and citizen;

d) business or community and business or community; and

e) business or community and citizen.

Whilst this standard does not cover data sharing between citizen and citizen, cities should make provision to allow a citizen to make requests related to the data it holds and shares. The city should also be able to respond to this request in a timely manner and keep an audit trail of these interactions.

4 Types of data

4.1 General

As local authorities transition to becoming smart cities, existing data assets form the initial data framework that is used as the initial evidence base for decision-making based on data. The city collects, processes and validates data for the essential operation of services provided to citizens. This city data estate resides largely in disconnected legacy systems which are cumbersome and costly to change and cannot be operated in new ways. Some investment is required in technology to unlock the value of data that resides in these legacy systems. This transition is not technology-led – rather technology is an enabler – it is data-led.

This is to allow the existing city data to continue adding value, alongside the new data which the city creates, for example from sensors forming part of its new transport infrastructure.

Understanding the data assets of a city is the first step in creating value from the data and maximizing the value of the data assets to the city. Concepts, of themselves, are not sufficient to derive value from city data and it is important to understand that the physical location of the data – the technology in which the data resides – is not the issue. Irrespective of the source and state of the data assets in a city, a common data framework can be created that reflects the data estate from which the city can derive value. This requires a data-centred approach – a new way of thinking about data – that develops the SCCM model articulated in ISO/IEC 30182.

Unlocking value from data requires the city to understand the value that can be created from data beyond the dataset approaches which prevail within cities, and indeed across regions, territories, and nations.

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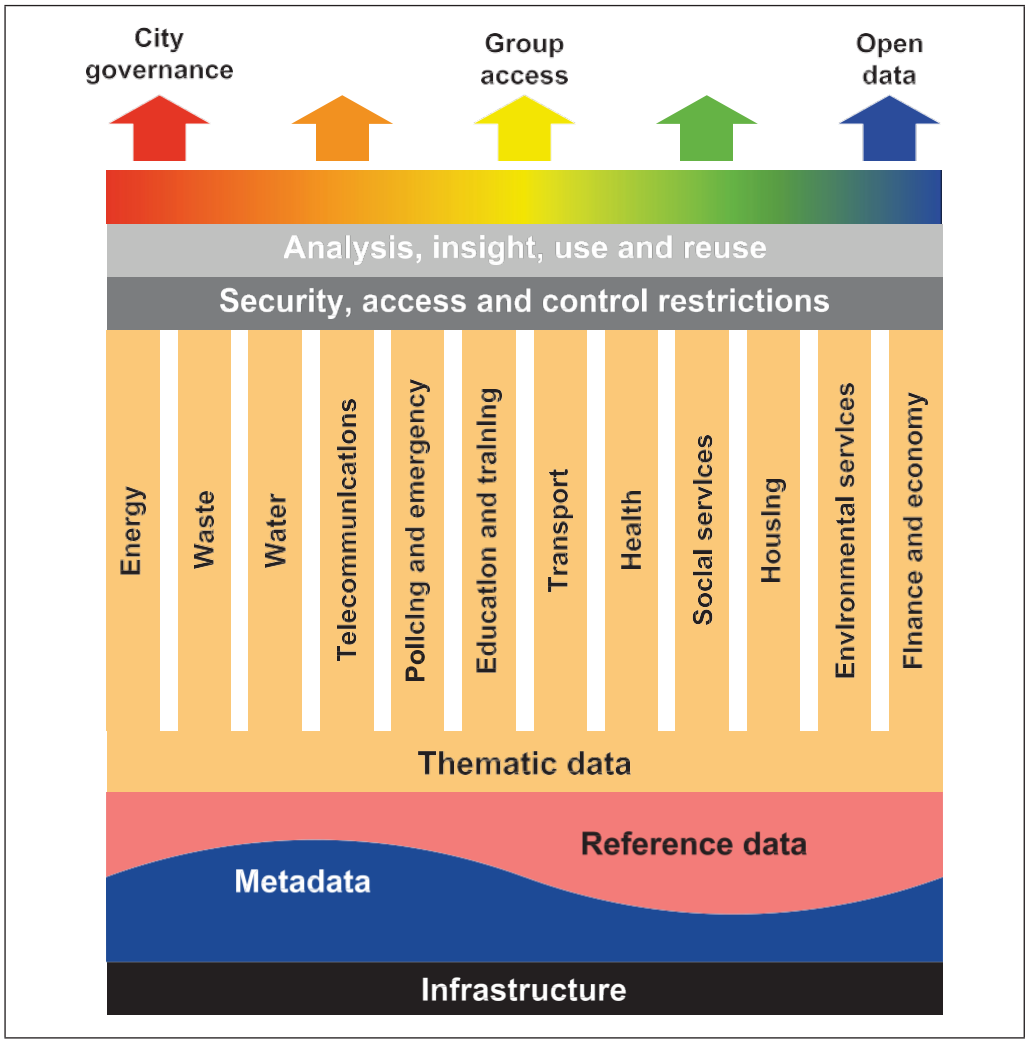
4.2 The data framework

4.2.1 General

As shown in Figure 1, the data framework for a smart city classifies the data assets as either metadata, reference data or thematic data. The data framework shows how current city data assets are transitioned from the existing siloed service provision to an interoperable data estate. The data framework also supports the collection, processing and analysis for future heterogeneous data streams that will become the norm as we transition to a connected Internet of Things landscape.

The data framework supports the active management of data across the entire data lifecycle (see Clause **7**, where the data value chain is covered in detail).

Figure 1 **Data framework**



4.2.2 Infrastructure

Infrastructure is a system of facilities, equipment and services required for the operation of a city. This encompasses both physical and data infrastructure, and all resources including technical, supporting services and people which are required to support the successful delivery of city services.

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Governance of infrastructure in a smart city is complex due to the multi-agency operating model which can comprise of many organizations who are likely to have differing approaches to Information Technology (IT) governance. ISO/IEC 38500 contains the guiding principles each organization providing smart city infrastructure can use. It focuses on both the current and future use of IT including management processes and decisions related to the current and future use of IT.

4.2.3 Metadata

Metadata is used to summarize basic information about data to enable it to become more easily discoverable by both humans and computers. Metadata can facilitate understanding of the provenance of data within the data framework and support appropriate data policies, licenses and regulation. An example of metadata in a smart city data framework is the data relating to the voluntary services organizations who deliver city services on behalf of the city to citizens. Metadata exists in all cities but the availability of metadata might differ depending on the size of the city, whether the city is predominantly urban, rural or is in a coastal setting, and the maturity of the city's data framework.

Metadata has the added value of being able to be used for analysis and comparison purposes across a number of cities, or indeed at national level. When metadata is shared, consideration should be given to any metadata which has been created and the data framework updated to reflect the security, access and control rights to be considered for the metadata created.

4.2.4 Reference data

Reference data usually consists of a list of permissible values and/or textual descriptions and is used by a business process to drive value from data. This requires an agreed vocabulary approach in order for this data to support the business processes across the many services, organizations and departments in a city. In a smart city data framework there are organizations who supply a number of services to the city, or products/services which are operated as shared services by the city. An example of smart city reference data is that of a vehicle specification about a transport fleet used to determine its suitability to meet a number of service needs. This reference data is unlikely to be unique to a specific city, however because it is relevant to a specific service provision and might be based on legacy approaches, it is unlikely to be useful for cities to use for comparison or benchmarking across cities.

4.2.5 Thematic data

Thematic data in a city will initially be the datasets and legacy data that are created, processed and managed by the city in order to deliver services to citizens, such as the data related to the provision of adult care services. The metadata and reference data within the data framework with the thematic data supports the city as it moves towards the provision of citizen-centric services for adults with all data becoming part of the wider healthcare service data for the city. At this point, it becomes possible to consider attributes that exist across a number of city services, allowing a city to understand the characteristics of the thematic data and what constitutes a set of data for the city service. In this scenario, healthcare service data forms a set of data in a city which of itself has specific value, and allows a city to understand the challenges and opportunities which exist.

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4.3 The data spectrum

4.3.1 General

In order to understand how a city can maximize the value of its data, it is important that the data framework classifies data for use and also differentiates the data it holds on the basis of whether it is considered closed, shareable or open. The extent to which the restrictions have been implemented can vary dependent on the security, access and control requirements. The use of data within the data spectrum is restricted to the use, reuse and the purpose for which data can be shared. ISO 31000, *Risk management - Principles and guidelines* outlines good practice on the management, assessment and analysis of risk and can be used by cities when implementing the data framework.

An appropriate risk management regime for the sharing, publishing and reuse of data should be established and implemented.

4.3.2 Closed data

Closed data is data which has been restricted for use. This data has been designated as information that is not permitted to be shared. In a city, this data includes payment details for citizens within a specific service, such as their council tax.

4.3.3 Shared data

The shared component of the data spectrum is the data which exists which cannot be considered as either open or closed data. This varies between cities and is assumed to represent the majority of the data in a city.

This standard looks in detail at:

a) the suitability of sharing data for new purposes (see Clause **9**); and

b) access rights to data (see Clause **10**).

It is important as part of the data spectrum to understand there are three top level access restrictions which apply to shared data:

1) specific access is when data is made accessible by the data owner to either named individual(s) or named organization(s);

2) group access is when data is made available to specific groups of people or organization(s) based on predetermined criteria; and

3) public access is when data is made available publicly but only under certain terms and conditions that cannot be considered open.

Publishers of city data have a duty of care when restricted data is considered for sharing to ensure that potential harm to individuals or assets is considered prior to publication. An example of shared data such as this is COMAH (control of major accidents and hazards) data.

Case study 1 in Annex A gives an example of the benefits of shared data with public access.

4.3.4 Open data

This standard uses the definition of open that is maintained by the Open Project [3)]. "Open" means anyone can freely access, use, modify and share for any purpose (subject at most to requirements that preserve provenance and openness). This definition is also used to determine whether data can be classified as open data.

Case study 2 in Annex A gives an example of a city publishing open datasets.

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4.3.5 Data usage

For all types of data within the data framework, it is important to consider the data usage when deciding on the value that is created from that data. Metadata and reference data determine the provenance of the data and in particular its state, for example raw, processed or archived. In some cases it is appropriate to use static data (a snapshot of data created to be used for some future purpose). Temporal data (data that varies over time) might also be used to create snapshots of scenarios in a city for future use. Versioned data (data that represents a data update cycle) might also inform scenarios and should also be considered in a city.

Consideration should also be given to the data structures used within the data framework when determining the data usage. This is covered in more detail in Clause **11**. Temporal and versioned data is important in order to understand the patterns of data which form the four key types of data insight required when sharing data in a city:

a) operational insight examines the characteristics of things such as buildings, communities and organizations, using data to evidence and improve their value for the city or deliver a service;

b) critical insight is gained from the real-time monitoring of incidents and current cases, involving all relevant organizations from across sectors, who work together to achieve the desired outcome or response or deliver a service;

c) analytical insight is the exploration of the data framework to determine patterns, correlations and predictions, allowing the development or innovation of systems or services, or the evidencing of challenges and opportunities for the city; and

d) strategic insight is the overarching approach that examines outcomes related to strategic objectives, decisions and plans.

4.4 Derived data

One aspect of smart city data sharing that is still largely untapped is the role of derived data and how it can contribute to the value of city data. Derived data has traditionally been created to support the performant processing of data attributes for processing. Derived data is when one or more measures used by a city are combined from one or multiple datasets to create new data attributes, which are then used during the exploration of data and appear in any resultant analysis.

As part of the processing that is performed to achieve the four key types of data insight, derived data is created as snapshots for particular scenarios, allowing the appropriate data to be explored for insight. Derived data is a key resource that a city uses to understand and respond to the challenges and opportunities experienced. For example, education data might be used along with transport data to gain strategic insight from the derived data about potential impacts on education provision when planning major city infrastructure initiatives.

Data creators and decision-makers should be aware that there are risks associated with the aggregation of data, by accumulation and/or association. This might result in derived data being created that relates to, or reveals sensitive information. It is important to ensure that any change or creation to the derived data is re-examined in order to ensure whether it is allowed to be shared or published.**Commercialization of data**

4.4.1 General

The open data movement has articulated that making data available free and open at the point of use adds value for the owner of that data and allows entrepreneurs to extend existing businesses or begin new companies to monetize the open data by adding value. The data within the data framework which should be considered for

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commercialization extends beyond open data to consider shared data. These valuable resources created from the smart city's data framework require curation and add significant value by creating social, economic and environmental resources for the public good. The data created in a city are not just created by the city but by organizations which support the delivery of services in the city from either

the private or third sector. Putting the data into the data framework creates visibility and facilitates unforeseen exploitation. The use of this shared data as part of a commercialization model will require negotiations with all the data creators involved. To ensure the continued curation and publication of this data – particularly at city scale – it will require a new approach that provides sustainable funding. Sustainable funding would address the ongoing cost associated with the evolution of city data and its usage.

4.4.2 Demand-led model

The initial supply-driven approach to making open data available, as a result of the work of the Open Data User Group (ODUG) has been superseded not just in the UK but globally. The new approach is a demand-led approach to the

curation and publication of open data. This demand-led approach is based on the publication of data for which there is an audience who can articulate the value of the release of the data.

Case study 3 in Annex A gives examples of some of the benefits of a demand-led model.

In a smart city context, a new approach is needed to data curation and publication if the initial building block created by the release of open data from cities is to be extended to include not just open data, but shared data.

There is an opportunity for cities to evolve commercial models for data that they curate and publish. This commercial opportunity exists for the combination of open and shared data and business models should be used to add value beyond the four levels of insight (see Clause **4**) for the city and city services. The city should examine business models that build on the open data already released and include any or all of the shared access data that the city holds, where access is currently restricted.

As evidenced with the open data agenda, a supply-led approach to these new models is unlikely to lead to a commercial funding model that contributes to or wholly funds the curation and publication of data shared commercially by a city.

A demand-led approach should be used for city shared data; this can also highlight the commercial opportunities to collect, process, curate and publish new shared city data.

As depicted in Figure 2, the commercialization opportunities diminish in direct proportion to the closing of data. In a city where the curation and publication approach results in the majority of data that could be shared remaining closed, this limits the commercial opportunities. By contrast, a city which explores the opportunities which exist with both open and shared data will be able to evolve new commercialization models to fund the data framework.

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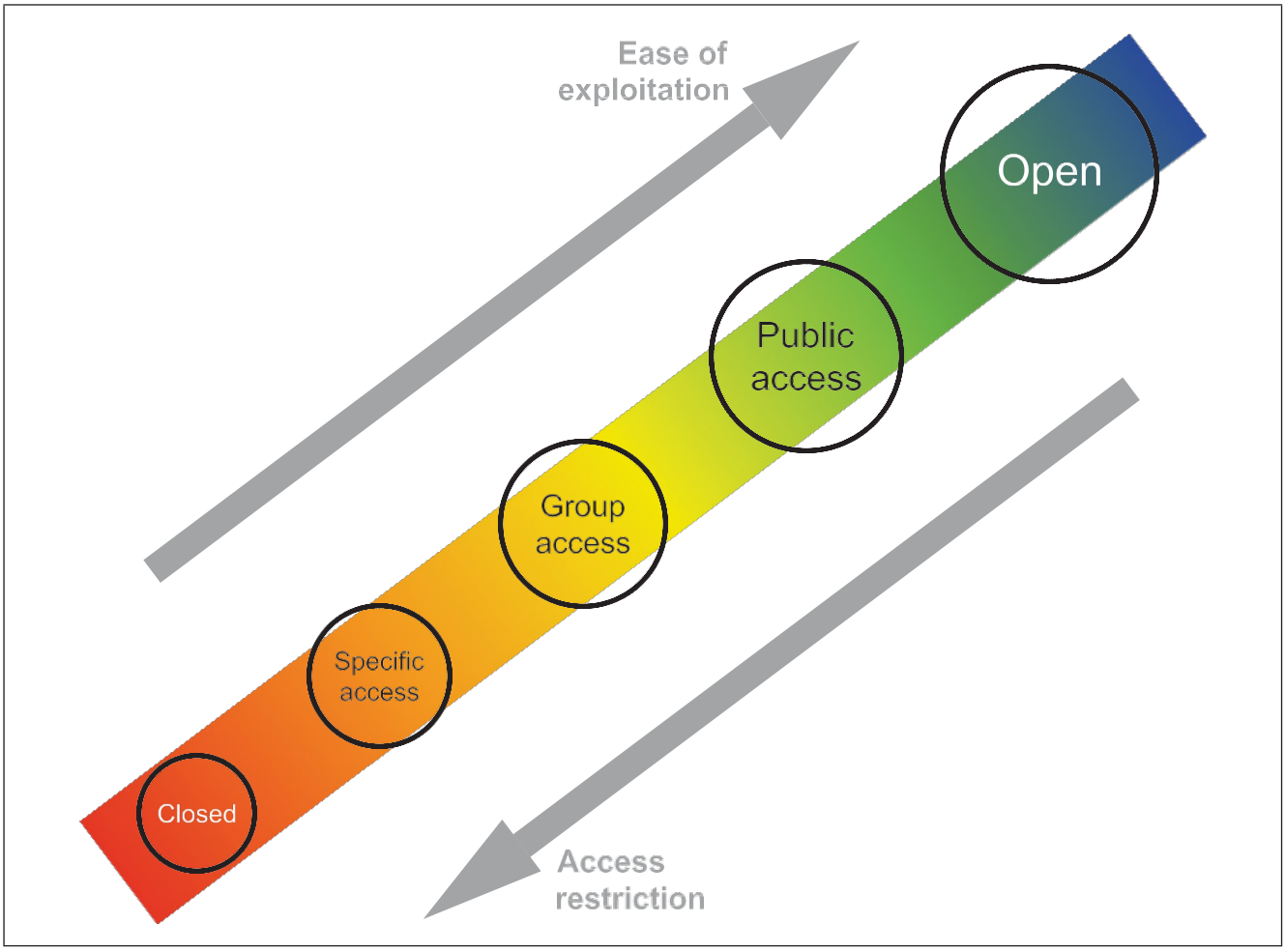
Figure 2 **Commercial opportunities for the data spectrum**



4.4.3 Commercial models

One of the keys to unlocking the demand-led open data agenda was the need to understand who consumed the data that had already been released, and to provide a mechanism for any citizen to request more data based on the presentation of a use case. Many countries are now using the demand-led approach to open data pioneered by ODUG. This approach has the additional benefit for cities in that it prioritizes requests for data with the data framework.

The creation of an evidence base that understands the demand, showcases what data exists and makes that data discoverable, helps a city determine the commercial value of shared data. This can allow commercial models based on incentivizing the safe and secure sharing of data to be developed.

Case study 4 in Annex A showcases the exploration of a commercial model. Not all of the data in the data framework is necessarily chargeable: the city as the authoritative source of this data should consider which data might be released as searchable and open, as this evidence of demand can highlight further commercial opportunities.

4.4.4 Research-based model

A research-based approach to commercial opportunities for city data should also be explored. This requires an investment to explore the data that a city holds using statistical, mathematical and data science techniques, however this investment could

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