OPEN FOR FEEDBACK

Exploring the development and impact of open standards for data

A report presenting the findings of our desk research into standards development

Open Data Institute

Contents

About

This report is part of a research programme funded by Innovate UK. The project aims to make it quicker and easier for organisations to create open standards for data, and to ensure that the standards they create achieve better adoption and wider impact.

The report has been researched and produced by the Open Data Institute, and published in February 2018. If you want to share feedback by email or would like to get in touch, contact the open standards project lead Leigh Dodds at leigh.dodds@theodi.org.

How can it be improved? We welcome suggestions from the community in the comments.

Introduction

Open standards for data are documented, reusable agreements that help people and organisations to publish, access, share and use better quality data. This report explores the development of open standards for data and their impact by examining existing open standards.

The goal is to make it easier to discover and develop new open standards for data by identifying resources that support organisations developing them.

Data such as statistics, maps and real-time sensor readings help us to make decisions, build services and gain insight. Data infrastructure will only become more vital as our populations grow and our economies and societies become evermore reliant on getting value from data.[1]

Data infrastructure consists of data assets, the organisations that operate and maintain them, and guides and processes describing how to use and manage that data. Trustworthy data infrastructure is sustainably funded with oversight that provides direction to maximise data use and value, meeting society's needs.

A strong data infrastructure is critical in fostering business innovation, driving better public services and creating healthy, sustainable communities. High-quality data being sustainably published in standard formats is an important element of a strong data infrastructure. Publishing data using common, consistent language, identifiers and formats will make it easier for people and machines to access, use and share it.

Standards provide a way to describe agreements around the use of common language and common formats. By 'open standards', we mean standards described by the International Telecommunication Union (ITU), the United Nations specialised agency for information and communication technologies, as: "standards made available to the general public [and] developed (or approved) and maintained via a collaborative and consensus driven process".

This report summarises research carried out by the ODI to explore different types of data standards, the people and processes involved in their development and the potential impacts of creating standards to strengthen our local, national and global data infrastructures.

Who is the intended audience for this research?

This report should be relevant for anyone interested in learning the answers to one of more of the following questions:

- What are open standards?
- Who develops open standards?
- What research and resources exist for developing open standards?
- What barriers are faced when developing open standards?
- What are typical processes used to develop open standards?

[1] Open Data Institute (2016), 'What is data infrastructure?', https://theodi.org/what-is-data-infrastructure

In answering these questions, we hope to provide support and insight for anyone involved in creating or developing open standards for data.

How did we scope our research?

To guide our desk research, we set out with the following objectives:

1. Challenge our assumptions around the potential challenges associated with developing standards, based on our own experiences of standards development
2. Clearly define what we mean by ‘open standards for data’
3. Understand who is involved in developing open standards for data
4. Understand how open standards for data are developed
5. Review existing research on standards, open standards and open standards for data
6. Review existing guidelines, recommendations and resources for developing open standards for data
7. Identify any gaps in existing guidance to inform future work on standards

What are standards?

Standards are all around us and we use them every day without realising.

When you address a letter, flick a light switch, or look up train times, you are using a standard or something based on one. Standards are used in thousands of sectors worldwide to capture agreements on physical things, conceptual ideas and digital products and processes.

Standards are documented, reusable agreements.[2] These detail the language, vocabulary, concepts, rules, processes, guidance or results that have been agreed by a specific community, to solve a specific set of problems.

Standards are used when it is important to maintain consistency, repeatability, support comparison, or shared understanding.

Everyday standards include:

- standards for electrical sockets and appliances
- letters addressed in the same format
- standard units of measurement for drinks in bars
- nuts and bolts

What are open standards?

Open standards are standards that are available for anyone to access and use. Open standards are described by the International Telecommunication Union (ITU), the United Nations specialised agency for information and communication technologies, as: “standards made available to the general public [and] developed (or approved) and maintained via a collaborative and consensus driven process”.

Following OpenStand principles,[3] open standards are:

1. **Cooperative** – developed with respectful cooperation between standards organisations

2. **Principled** – developed in the open and prioritising due process, transparency, consensus and balance of influence

3. **Collective** – committed to collective empowerment on a global scale by boosting interoperability, enabling competition, enabling communities and forming the foundation for future innovation

[2] BSI, ‘What is a standard and what does it do?’, https://www.bsigroup.com/en-GB/standards/Information-about-standards/what-is-a-standard
[3] OpenStand, ‘Principles’, https://open-stand.org/about-us/principles

4. **Available** – available for use under fair terms, from royalty-free to fair, reasonable, and non-discriminatory terms (FRAND)

5. **Voluntary** – adoption by the community is voluntary and success is determined by the market

To enable reuse, standards owners might waive their copyright, or publish a standard under an open licence or other arrangements that allows for FRAND of the standard.[4]

What are open standards for data?

Standards are used for many applications, from compatible infrastructure to publishing information. But this report focuses on standards that help people to publish and consume high-quality data.

Standards are an important element of a strong data infrastructure. They underlie everything we do, informed by the flow and use of data, statistics and information that helps us make decisions, see the bigger picture, and build products and services. High-quality data strengthens the data infrastructure, and open standards for data can help improve data.

> *An open standard for data is a documented and reusable agreement that supports the publication and exchange of data.*

Some open standards are intended to support the publication of open data. But they can be used to support publication of data from across the Data Spectrum – from closed, to shared, to open – depending on how data is licensed.[5] The important characteristic of an open standard for data is that the standard is available for use under an open licence or fair terms.

This report includes prominent but restricted standards, which provide important lessons about how open standards for data are developed.

Common features of open standards for data

An open standard for data is a documented and reusable agreement to support publishing, sharing or storing data. This agreement can include:

- **Concepts** – what concepts are in scope and how are they defined?
- **Content** – what information should be modelled or shared?
- **Rules** – what concepts and information are required (or not) to be present in data that conforms to the standard?
- **Processes** – how should data be collected and exchanged?
- **Formats** – how is the data arranged to enable sharing and reuse? For example, what are the file types and data structures?

[4] ThinkTank (2013), FRAND, https://webgate.ec.europa.eu/fpfis/mwikis/thinktank/index.php/FRAND
[5] Open Data Institute, 'The Data Spectrum', https://theodi.org/data-spectrum

Characteristics of open standards

Thousands of open standards for data are used every day in a variety of sectors.[6]

Open standards for data tend to be developed so organisations can:

- agree on common models or a common language
- consistently publish information
- streamline information aggregation
- create social change or implement policy
- promote common understanding

Are standards mandatory or voluntary?

The OpenStand principles state that open standards should be voluntary and their success is based on market adoption and their perceived impact.[7] Open standards can become a *de facto* standard when there is extensive adoption that leads to market pressure to adopt it.

However, in some cases standards may become mandatory. This primarily happens through legislation. For example, the Brownfield Site Register Open Data Standard is mandatory for local planning authorities.[8] This type of standard is known as a *de jure* standard.

Which sectors and types of organisations are creating open standards?

Open standards are developed and used by a variety of organisations, ranging from government to civil society, business to charities. Open standards can be developed to support government and civic services, business and industry initiatives, or to support academic research.

[6] GovEx and Geothink, 'Open Data Standards Directory', http://datastandards.directory
[7] OpenStand, 'Principles', https://open-stand.org/about-us/principles
[8] Ministry of Housing, Communities & Local Government (2017), 'Brownfield Land Registers Data Standard', https://www.gov.uk/government/publications/brownfield-land-registers-data-standard

What role do open standards play in data infrastructure?

In general, open standards for data are intended to be used in specific ways. Agreeing on the scope and purpose of a standard is the initial starting point for its development.

We grouped open standards for data into three groups: providing guidance only – for example, BSI PAS 182 Smart city model,[9] supporting shared language – for example, 211 Taxonomy,[10] or supporting publishing data – for example, the General Transit Feed Specification (GTFS).[11]

Standards that provide guidance

Open standards like BSI PAS 182 Smart city model provide guidance and recommendations on how to make data work better together, develop a common, language or map concepts to data. Outputs include data dictionaries, concept models and shared vocabularies.

Standards that support shared language

Standards like 211 Taxonomy support mapping concepts and terms to their predefined model. The model can be as simple as a list of defined terms or as complex as an ontology. Outputs include codes that support the use of standardised and common terms in data.

Standards that support exchanging data

Open standards like GTFS are for producing data from existing data sources to a common format. They tend to include both guidance and concept models. Outputs include datasets using the standard format, produced with the guidance model and containing agreed terms.

[9] BSI, 'PAS 182 Smart city concept model', https://www.bsigroup.com/en-GB/smart-cities/Smart-Cities-Standards-and-Publication/PAS-182-smart-cities-data-concept-model
[10] 211 LA County, 'Welcome to the taxonomy website', https://211taxonomy.org
[11] Google Transit APIs, 'GTFS Static overview', https://developers.google.com/transit/gtfs

Open standards for data case studies

To understand how open standards are developed, implemented and described, we developed three in-depth case studies.

There are thousands of open standards[12] available for implementation and use. To understand how open standards are developed, implemented and described, three in-depth case studies were developed alongside this desk research. Our standards case studies provide a summary of the history, development process, governance and key actors involved in the development of an open standard for data.

Case study: Google's General Transit Feed Specification (GTFS)

What if it was as easy to find public transport information as it is to get driving directions? This question is at the heart of GTFS, the standard for transit data. Every time you use CityMapper, Google Maps or even ride-sharing apps like Park.io, you rely on GTFS.

GTFS and GTFS-RT extension are open and common formats for sharing public transport information: transit schedules with associated geographic information (GTFS) and real-time transit updates (GTFS-RT).

Read more in the full General Transit Feed Specification (GTFS) case study.

Case study: BSI PAS 182 Smart city concept model

How can people who make decisions on services and those providing services speak a common language so they can exchange the information needed to improve a city's urban spaces?

PAS 182 helps local government and providers create common concepts and language to make their data work together. From a common model of the city, smarter decisions can be made that strengthen the city's data infrastructure.

Read more in the full BSI PAS 182 Smart city concept model case study.

[12] GovEx and Geothink, 'Open data standards directory', http://datastandards.directory

Case study: Brownfield Site Register Open Data Standard

Where are the sites in England suitable for redevelopment and what condition are they in? Understanding the place and shape of brownfield land – that is land suitable for redevelopment – is the driver behind this standard. UK Government has said that building new homes is necessary to fix our broken housing market and having the right information plays a major role in that success.[13]

Read more in the full Brownfield Site Register Open Data Standard case study.

In this report, we also include case studies featuring other open standards for data, which are set out in the following section. These case studies demonstrate the impact of open data standards on policy, technology, society and the economy.

[13] Ministry of Housing, Communities & Local Government (2017), 'Policy paper: Fixing our broken housing market', https://www.gov.uk/government/publications/fixing-our-broken-housing-market

The impact of open standards

Standards can have far-reaching impacts beyond their role as technical productions. They can be used to drive collaboration, implement policy and disrupt industries.

Open standards for data are typically technical products consisting of a specification, a schema, a data model, a vocabulary, or an informal list of rules. As a technical product, their immediate impact will also be technical, helping to supporting the publication and exchange of data.

However, standards can have far-reaching impacts beyond their role as technical productions. They can be used to drive collaboration, implement policy and disrupt industries. In the following sections, we have identified a variety of technical, economic, social and policy impacts of standards.

Technical impacts of open standards

Standards can enable publication of new data

'Which datasets should I publish?' and 'How should I publish them?' are questions frequently asked by data publishers looking to publish open or shared data.

Open standards for data can give first-time publishers an idea of the types of data that other organisations publish. They also act as a guide that helps people to publish data in consistent ways to enable reuse. This guidance can encourage data that was previously closed or shared to be published openly, building confidence among publishers that they are publishing their data in useful ways.

Added incentives to publishing data in standard ways are new tools being developed and existing tools that provide direct benefits to the publisher – or their stakeholders – after publishing, as the following case study shows.

Case study: UK Department for International Development (DfID)

In 2010, DfID launched the UK Aid Transparency Guarantee (UKATG), committing the UK government to greater transparency and clarity on

international aid spending.[14] DfID committed to publishing comparable, accurate and timely open data, tracking where aid cash is spent, from the taxpayer to the beneficiary.

Partner organisations receiving grants or contracts from DfID must publish this tracking information using the International Aid Transparency Initiative (IATI), unless specifically exempted. The use of IATI as a standard for international aid by DfID and its downstream partners has lead to new data publication that did not previously exist. IATI publishers can be tracked on the IATI dashboard.[15]

Standards produce better quality data

Popular (quantitative) ways of measuring the success of a standard include counting the number of organisations who adopt an open standard for data, the number of open datasets produced using it, and the tools or services developed to support it.

It is more difficult to measure the impact of the open standard on data quality. In her book on executing data quality projects, Danette McGilvray defines data quality as "the degree to which data can be trusted for any required use".[16] For data to be good quality, it has to be the right data, at the right time, in the right place, presented to the right audience.

For most open standards, the data produced must contain the expected fields, use the correct codes, be published at the expected frequency, be complete and make sense to the data users. A good open standard for data provides the tools and support to help data publishers produce and check for good quality data, including tools to validate, preview, and compare data.

Open standards for data can advise data publishers how often data should be published or provide a way to share their publication schedules and how up-to-date their datasets are. Having similar mechanisms in place for where the datasets are located and how they can be accessed also improves data quality.

As open standards for data tend to focus on a specific topic or subject, good documentation and governance helps data users decide if the datasets published are right for their purposes.

A data publisher can provide all of the above and publish good quality data without standards. However, the use of standards gives data publishers access to shared tools, services and community support, reducing the barrier to entry so they can focus on improving data quality and data use.

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[14] Department for International Development (2015), 'Policy paper: 2010 to 2015 government policy: overseas aid transparency', https://www.gov.uk/government/publications/2010-to-2015-government-policy-overseas-aid-transparency/2010-to-2015-government-policy-overseas-aid-transparency
[15] IATI (2018), 'IATI Publishers', http://dashboard.iatistandard.org/publishers.html
[16] McGilvray, D. (2008), 'Executing data quality projects', http://www.gfalls.com/ten-steps-data-quality-book

Case study: US Environmental Protection Agency

The US Environmental Protection Agency (EPA) collects environmental data from a number of organisations in its role as a federal agency protecting human health and the environment. Information from individual states, local agencies, tribes, and other organisations was incompatible, causing data integrity issues and increasing cost per transaction of electronic reporting.

The EPA developed data standards and the Central Data Exchange (CDX) platform to address issues of data quality and cost.[17] The EPA case study describes the benefits of using open standards for environmental data, including improved consistency and reduction of redundant data.[18]

Standards encourage new tools and services to be created

When data is published inconsistently there can be a high cost involved in taking data from new data sources. For example, there are 353 councils in England required to publish information on grants.[19] As each dataset is different, aggregating data on grants becomes an expensive activity for anyone using the data.

Publishing consistently reduces the costs associated with using new sources. It can also encourage new tools and services designed to take advantage of data that conforms to a specific standard to be created.

Tools might include software that supports data to be visualised or analysed. Services might include aggregators or other intermediaries that offer value-added services that enrich the data or provide new ways to interact with it. These tools create an ecosystem around the standard that can drive adoption or create new business models.

Case study: Building and Land Development Specification

The Building and Land Development Specification (BLDS) standard focuses on publishing building and construction permit data consistently in the US, where each state collects data differently.[20] The standard was developed collectively by technology and building services companies in the private sector, and US state governments.

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[17] U.S. Environmental Protection Agency, 'Central Data Exchange', https://cdx.epa.gov

[18] U.S. Environmental Protection Agency, Office of Environmental Information, Office of Information Collection (2012), 'Environmental Protection Agency Central Data Exchange', https://project-open-data.cio.gov/epa-case-study

[19] LGiU, 'Local government facts and figures', https://www.lgiu.org.uk/local-government-facts-and-figures/ and Local Government Association (2015), 'Local transparency guidance', https://www.local.gov.uk/our-support/guidance-and-resources/data-and-transparency/local-transparency-guidance

[20] BLDS, 'BLDS Data Specification', http://permitdata.org

Development began in 2015, with collaborators including Zillow, BuildFax, Socrata, SiteCompli, Accela, CivicInsight, Buildingeye, and DriveDecisions. Since the standard's launch, housing and real-estate organisations have been joined by technology companies creating tools and services from the published data including Chicago Cityscape, ESRI, Junar, NuCivic, Open Counter, Ontodia, Vizalytics, CartoDB and more.

Economic impacts of open standards

Standards create new commercial ecosystems

From transit to procurement, health to weather, open standards create new commercial opportunities and ecosystems that encourage competition. By reducing the barrier to entry and cost associated with aggregating data in a particular sector, more organisations can enter the ecosystem to provide the necessary products and services. These include translation, conversion, aggregation, reporting, training, analytics, consumer products, business-to-business services, and more.

Case study: General Transit Feed Specification (GTFS) and Transit

In transit, Google leveraged its position as a market leader to launch the GTFS. It has become the *de facto* standard, superseding Transit Communications Interface Profiles (TCIP) and Service Interface for Real Time Information (SIRI)[21]. Part of the success of GTFS and its real-time extension GTFS-RT was assimilating competing and legacy standards with the production of tools to convert to GTFS and GTFS-RT seamlessly.

Standards can create ecosystems

Standards take data publications from bespoke items to commoditized products. Data users no longer need to customise code for each dataset. With a large enough community, the pipeline from data production to data use no longer needs to be internal – organisations can specialise in providing products and services for each step of the pipeline.

[21] Reed, L.T (2013), 'Real-time transit passenger information: A case study in standards development', https://smartech.gatech.edu/bitstream/handle/1853/50218/REED-THESIS-2013.pdf

Products and services for each step of the pipeline, from data publication to use:

- **Data production**: to map and convert legacy, closed and shared datasets to open standards
- **Data publishing**: to license and load datasets to online repositories, or open up direct access using interfaces like APIs
- **Data aggregation**: to collate and enrich data from different publishers and make it available for data users
- **Analytics**: to provide insight-as-a-service based on aggregated and enriched data

Adopting a data standard means an organisation can focus on providing value at any stage along the pipeline that fits their business best. An additional benefit can be the certification of compliance from standards bodies acting as a badge of trust and competence.

Case study: OpenOpps and open contracting

OpenOpps is a platform providing access to worldwide procurement data. [22] It uses open data published in a variety of formats and rapidly adopted procurement data published using the Open Contracting Data Standard.[23] Through its API, organisations can access the procurement information they need and avoid the steps in the pipeline that aren't necessary for their scenarios or needs.

Standards open up markets

The adoption of open standards for market-critical data can cause a powershift in the market. Open standards can help to disaggregate authority: stakeholders (including market leaders and authorities) exchange bespoke and proprietary standards for cooperatively produced and shared standards. Disaggregation of authority levels the playing field for data production and data use, allowing new uses of data and new entries to the market.

[22] OpenOpps, 'OpenOpps.com – Never miss an opportunity', https://openopps.com
[23] Open Contracting Data Standard (2017), 'Open Contracting Data Standard: Documentation', http://standard.open-contracting.org/latest/en

Case study: General Transit Feed Specification (GTFS) and transit

Before Google launched GTFS-RT,[24] other standards existed that supported real-time transit information exchange: SIRI (Service Interface for Real-Time Information) in Europe[25] and TCIP (Transit Communication Interface Profiles).[26] GTFS and its extension GTFS-RT have become *de facto* for transit thanks to open datasets being widely adopted and produced around the world.

The standardisation of global transit data supports trip planning tools like Citymapper, platforms like Open Trip Planner, research and other uses.[27] There is also a market for developing programs that translate from SIRI, TCIP and other transit standards to GTFS and GTFS-RT, and vice versa.

Standards reduce costs associated with data

Using data, including open data, means taking the time and resources to get the data, understand it, transform it to meet your needs and maintain processes over time. Publishing data also comes at a cost, from deciding what to publish to supporting use of the data and maintaining processes over time.

Open standards for data can have two main impacts on data use.

1. **Reducing the cost of data production** – By adopting a standard, data publishers reduce the work of deciding what to publish and preparing custom documentation. A good data standard developed with a community of interest can reveal gaps in the data so they can improve their internal data use. The costs of understanding the standard, and mapping their data to it, still remain but should be lower than a bespoke publication. Once internal data is mapped to a standard, data publishers can focus on improving the quality of their data publications rather than tweaking the structure of their datasets to meet data user needs.

2. **Reducing the cost of data use** – For a single publication, having good documentation and a wide community of support reduces the cost of data use. The savings increase as more publications use the same standard. There is no need to re-learn how the data is modelled or change the processes used to transform the data. Data users can focus on how to use the data for maximum impact rather than re-learning the quirks of how data is represented in individual datasets.

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[24] Google Transit APIs, 'GTFS realtime overview', https://developers.google.com/transit/gtfs-realtime
[25] SIRI (2013), Service interface for real-time information: CEN/TS 15531 (prCEN/TS-OO278181), http://user47094.vs.easily.co.uk/siri
[26] APTA, 'Transit Communications Interface Profiles (TCIP) standard development programme', http://aptatcip.com
[27] Center for Urban Transportation Research, University of South Florida (2010), 'The many uses of GTFS data', http://www.locationaware.usf.edu/wp-content/uploads/2010/02/The-Many-Uses-of-GTFS-Data-%E2%80%93-ITS-America-submission-abbreviated.pdf

Case study: UK Local Authority Spend

In the UK, every local authority must publish spending over £500[28]. Without a standard, anyone trying to understand regional, national or UK-wide spending has to examine each dataset to combine them. Datasets from the same local authorities are not always consistent over time. This increases the cost of using the data. In 2015, the Department for Communities and Local Government provided guidance on what to include as part of the local government transparency code 2015.[29] The guidance is supported by a standard: the Expenditure exceeding £500 scheme.[30]

Policy impacts of open standards for data

Standards can support policy to be implemented

Policy affects the norms, environments, and operation of communities, organisations and systems. Open standards for data can help to support public and private policy objectives by enabling the publication and use of data that will, for example:

- help to change markets and improve services: the UK's open banking standard was imposed by the competition regulator to create a more competitive and innovative banking standard
- help to deliver better public services by enabling open innovation and more competitive markets
- make it easier to gain insight into the impacts and performance of government policy, e.g. through publication of relevant statistics across multiple government organisations to an open standard

Case study: Common Alerting Protocol (CAP)

Following the boxing day tsunami disaster in 2004, the Internet Society (ISOC) launched a collaborative effort to agree on an internet-supported, worldwide standard for public warnings. The collaboration, sponsored by FEMA, featured diverse collaborators but met resistance from supporters of established protocols.[31] The standard is now widely adopted, in part because CAP supports each organisation's internal policy while providing a common, international protocol.

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[28] Local Government Association (2015), 'Local transparency guidance', https://www.local.gov.uk/our-support/guidance-and-resources/data-and-transparency/local-transparency-guidance

[29] Department for Communities and Local Government (2015), 'Local Government Transparency Code 2015', https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/408386/150227_PUBLICATION_Final_LGTC_2015.pdf

[30] Local Government Association, 'Expenditure exceeding £500', http://schemas.opendata.esd.org.uk/Spend

[31] FEMA (2018), 'Common Alerting Protocol', https://www.fema.gov/common-alerting-protocol

Standards can embody legislation

Standards are increasingly important in legislation. In the past, governments mandating that organisations publish data have focused on what data should be published, but not on how. This has lead to situations where disclosure is widespread but the data is difficult to collate and use for intelligence and insight.

By adopting open standards for data and linking them to legislation, governments can close the utility gap, provide clear guidance on how to disclose data, and automate compliance checks, data aggregation and reporting. Open standards for data provide clarity to data publishers, the opportunity for stakeholder engagement and help ensure consistent and comparable results.

As with any standard, governments need to be careful about which standard is adopted and when. Choosing the wrong standard, or mandating it too early, can stifle innovation. Sometimes governments will need to work with stakeholders to encourage a standard to be created or adopt an existing open standard developed by the market. Typically, governments will link a standard to secondary legislation or a code of practice which can be changed more easily than primary legislation, or simply state that a standard should be adopted and nominate an organisation to be responsible for enforcing compliance.

Case study: Brownfield Site Register Open Data Standard

In 2017, the UK government launched the Brownfield Site Register Open Data Standard – a standard for publishing the location and condition of brownfield land, i.e. land that is suitable for redevelopment. Legislation is the driver behind this standard. By tying the standard directly to regulation four of the Town and Country Planning (Brownfield Land Register) regulations 2017, the standard directly supports the legislation.[32] The standard was developed in collaboration with local planning authorities, with tools available to validate and aggregate the data from data.gov.uk with minimal human intervention.

Social impacts

Standards encourage multi-stakeholder collaboration

At first glance, open standards for data can seem like a purely technical exercise. But to develop a standard that is useful to the community and used by stakeholders, open standards development needs people and multi-stakeholder collaboration.

The stakeholders can include the owner of the standard, the sponsor funding the standard, the developers of the standards and others who work together to create the standard. Stakeholders also include the people and organisations who implement the

[32] The National Archives (2017), 'The Town and Country Planning (Brownfield Land Register) Regulations 2017', http://www.legislation.gov.uk/uksi/2017/403/regulation/4/made

standard, use any data published to the standard, provide third-party support, develop new businesses based on the standard, among others.

With facilitation and guidance, multi-stakeholder collaboration improves open standards for data at every stage, from the first idea of standardisation through development, rollout and ongoing maintenance.

Outside the development cycle, multi-stakeholder collaboration connects people and organisations working in the sector. Data publishers are interested in who else publishes data using standards so they can understand how issues were overcome and improve their processes. Data users are interested in connecting with other data users with similar goals or issues. Here, open standards for data can provide opportunities to make connections.

Case study: Data surgeries

360Giving, the standard for grant making in the UK, regularly convenes invitation-only workshops for data publishers, philanthropists and grant-making organisations to meet, discuss problems and share lessons. It doubles as an opportunity to gain new publishers when interested organisations learn about their peers' experiences as data publishers.[33]

[33] See: http://www.threesixtygiving.org

How are open standards developed?

Open standards are developed by a variety of organisations

Open standards are developed by a variety of organisations, from formal standards bodies that are nationally or internationally recognised, through to commercial market leaders, governments, trade association and other community bodies.

Standards developed by authoritative bodies like a national standards body or for sectors that are highly regulated like healthcare or telecoms,[34] tend to follow more formal and rigid processes. These standards are more likely to be *de jure* standards that are made mandatory by legislation, or backed by influential industry bodies.

The processes used by these organisations typically feature:

- detailed process documents
- rigid governance practices
- one or more working groups
- more use of formal language
- preference for tried and tested technology
- more points where committee approval is needed

At the other end of the spectrum, open standards developed by other types of organisations tend to respond to commercial or community needs. These standards are more likely to be voluntary and become *de facto* standards, due to the standard owner's influence, engagement with government and industry bodies, or through robust adoption by the community.

The processes used by these organisations typically feature:

- a preference for cutting edge technology that favours the digitally literate
- visible engagement with the community
- fewer process documents
- more flexible governance practices
- more use of language that favours the digitally literate
- fewer points where approval is needed
- visible change management using repositories like Github

[34] ITU-T, 'ITU-T Recommendations', https://www.itu.int/en/ITU-T/publications/Pages/recs.aspx

All standards development falls somewhere on a spectrum between formal and informal processes. However, despite this, they are very similar. Most standards processes involve a trigger to start the standards development, then a development stage, followed by a launch. If the standard is adopted, it may be regularly reviewed to keep it up-to-date and ensure it continues to meet the needs of publishers, data users and other stakeholders. When a standard is poorly adopted or no longer needed, it may be withdrawn, retired or abandoned.

Appendix 1, 'Comparing open standards development lifecycles', describes the life cycles from key open standards.

Scoping a standard

All standards development starts with an identified need to solve a specific problem through the creation of a documented, reusable agreement.

The reasons for creating a standard can include:

- **seeking change in a community, society or policy** – for example Open Contracting Data Standard's focus on opening up and monitoring public contracting[35]
- **policy or legal motivations set by government** – for example the UK's Brownfield Land Registers Data Standard that supports planning regulations.[36]
- **commercial needs to improve information flow** – for example Google's General Transit Feed Specification (GTFS) that supports global disaggregated transit information flow.[37]
- **solving a technical issue where common information is needed by a community of data users** – for example the challenge faced by the US Environmental Protection Agency (EPA) in the collecting and sharing of environmental data from a variety of organisations: Environmental Protection Agency Central Data Exchange.[38]

At this stage, a proposal may be developed by gathering a community of stakeholders to understand their needs, and to identify and prioritise requirements.

More formal processes will likely involve a standards owner, standards sponsor or a committee approving funds, scope and time limits. More informal processes are likely

[35] Open Contracting Partnership, 'Open Contracting Partnership', https://www.open-contracting.org
[36] Ministry of Housing, Communities & Local Government (2017), 'Guidance: Brownfield Land Registers Data Standard', https://www.gov.uk/government/publications/brownfield-land-registers-data-standard
[37] Google Transit APIs, 'GTFS static overview', https://developers.google.com/transit/gtfs
[38] Project Open Data (2012), 'Environmental Protection Agency Central Data Exchange', https://project-open-data.cio.gov/epa-case-study

to simply prototype the standard and/or seek consensus in their community to ensure there's enough interest to begin development.

Developing a standard

At this stage, development of the standard gets under way. This typically involves people and organisations with the technical expertise in data modelling required to create the necessary technical documents which include a specification, schema or model. Technical documents describe the features, functions and interfaces of the standard using concise language, code or diagrams. They can be supported by additional advice, tools and guidance. In some cases, the standards developer is also the standards owner and will take on this role.

The reason for developing a standard, the audience, stakeholders and type of standard all have an impact on the choice of development method.

The development stage can involve waterfall or agile methods. With a waterfall method, work on the standard is done in sequence, with stakeholder consultation at predetermined points. Agile methods favour rapid iterations with continual stakeholder involvement.

Formal standards bodies tend to favour a waterfall process, while non-formal standards organisations tend to use one of the following approaches:

- follow known standards development processes from authoritative bodies like W3C, BSI, US EPA, GSMP, IEEE, and BOMOS
- choose familiar agile methods
- not follow any particular development method and learn as they progress

BSI, the national body for standards in the UK, favour a waterfall method, using their Principles of standardization method. In contrast, Google, the corporation behind the General Transit Feed Specification (GTFS) favour agile methods with sprints involving domain experts.

Development progress and activity can be shared on repositories like GitHub, through documents or in-person at development workshops. Progress updates might be held back and only released at fixed stages, or might be carried out completely in the open.

The launch and adoption of a standard

A launch usually involves the release of a stable version of the standard's technical documents which can include a specification, schema or model, along with any additional advice, guidance, tools and other documentation.

Depending on how a standard has been developed, its launch can be the start of widespread engagement, advocacy and adoption. When a standard is developed in the open or with the bulk of the community involved, engagement and advocacy starts much earlier.

The launch stage is usually where standard development roadmaps split. Some standards plan to iterate and improve, so they continue to collect use cases, feedback and change requests. Other standards do not formally accept feedback or only collect this at a scheduled later date.

Standards developed using processes from authoritative bodies – such as W3C, BSI, US EPA, GSMP, IEEE, and BOMOS – tend to schedule reviews, while others tend to favour continuous feedback, which doubles as a form of engagement with their community.

Review and maintenance of a standard

Updates are sometimes needed to keep a standard current, to fix bugs, or to add new features so that it can continue to be useful to the community.

Some standards update as often as weekly or monthly. For example, modifications to the General Transit Feed Specification (GTFS) can take 14 – 30 days.[39] Others update periodically when the number of bug fixes or new features reach certain levels, for example the Open Contracting Data Standard. Others update on a schedule, for example BSI PAS.

To keep track of changes to the standard, the standard itself and supporting documents can use version numbers. Version numbers help keep track of minor changes that can include fixing errors or accommodating small improvements or major changes that have more impact by changing the version number, for example changing a '1' to a '2'. Version numbers can help people and organisations using the standard to keep track of changes by comparing the version they used to the most current.

Depending on how they are governed, updates can be approved by the community, the standards owner or a governance board set up for that purpose. Formal standards bodies tend to document detailed rules and conditions for updates, while non-formal standards organisations that have not adopted an authoritative standards process tend to have briefer governance documentation, if any (see the GTFS guiding principles). Rules for updates could be as brief as stating who approves standard updates and upgrades.

Many standards do not share clear guidance on how they will be maintained and updated. Those that do tend to feature governance boards, governance guidelines, standards roadmaps, or a review plan. These documents tell the community that the standard will be maintained, who will maintain it and what processes will be followed.

When a standard is not responsive to change requests but is openly licensed, other parties may decide to fork the standard to create new versions. This dilutes the standard's reach and integrity, reducing its ability to increase adoption and discouraging organisations from working together using the standard. An example of this is the Open311 standard in the US, which has seen many city-level adaptations diverging from the original standard.

Standards can be superseded by new standards, negatively impacted by changes in the sector or legislation, or fractured by adaptations. Standards can be retired intentionally, especially if there is no longer support for its ongoing adoption and development.

When a standard is intentionally retired, the standards owner makes an effort to flag this status to keep the community informed. Otherwise it is frequently up to potential

[39] Google Transit APIs, 'Overview of the change process', https://developers.google.com/transit/gtfs/guides/changes-overview

users to review the latest activity in community spaces or on the standard's website to identify whether a standard is receiving ongoing updates, or whether it has been broadly adopted.

Stakeholders in developing open standards

Standards are developed for a community and used by a variety of different stakeholders.

Standards stakeholders tend to be identified from groups in the community affected by the standard. For example, healthcare includes patients, practitioners, commissioning groups and more.[40]

In formal standards development processes, there is more consensus on the roles of different actors. Formal standards for data keep a lot of the historical vocabulary from standards development – these were developed for standards created for electrical engineering, mechanical engineering, and internet protocols, among others.

Several roles emerged from our review of different standard processes.

Standards owners

The people or organisations retaining the copyright, intellectual property or control of the standard. Their role is to steer the development and adoption of the standard. Standards owners are sometimes known as the standards body, standard developing organisation or standards development organisation.

- Alphabet's Google is the standards owner for GTFS
- Department for Communities and Local Government is the standards owner for the UK's Brownfield Land Registers Data Standard
- BSI is the standards owner for PAS 182
- Open Contracting Partnership is the standards owner for the Open Contracting Data Standard

Standards sponsors

The people or organisations paying for the creation, development or ongoing maintenance of the standard. Standards sponsors are sometimes called benefactors. The initial standards sponsor may not continue to support its maintenance long-term, or the funding model may change to include commercial activities or fundraising. A standards owner can also be the standards sponsor.

- Alphabet's Google is the standards sponsor for GTFS

[40] Intel ® Technology Journal (2009), Healthcare IT standards and the standards development process: Lessons learned from health level seven, https://www.healthit.gov/sites/default/files/archive/HIT%20Standards%20Committee/2010/2010-11-30/Intel_ITJ9%203%204_StatStd.pdf

- Department for Communities and Local Government is the standards sponsor for the UK's Brownfield Land Registers Data Standard
- Department for Business, Innovation & Skills (BIS) was the standards sponsor for BSI PAS 182
- The World Bank is an example of a standards sponsor that isn't a standards owner; they incubated the Open Contracting Data Standard

Standards developers

The people or organisations creating the technical documentation for the standard, providing ongoing technical support or both. Sometimes known as the standard architect, a standards developer can be the standards owner, an external company or a voluntary community effort.

- Alphabet's Google is the main standards developer for GTFS (alongside community contributions)
- Porism is the standards developer for the UK's Brownfield Land Registers Data Standard
- BSI was the standards developer for PAS 182
- Open Data Services Cooperative is the standards developer for the Open Contracting Data Standard

Standards boards

The people and services providing guidance and governance for the standard. Standards boards include committees and working groups like technical committees, governance boards and review panels. Standards boards are usually independent of the standard's owner, sponsor and developers. The board provides advice, votes on approvals or changes, and ensures the guidelines are followed.

Standards adopters

The people and organisations using the standard. For standards that provide guidance, these are the people and organisations that use the guidance to create new models to support accessing, using and sharing data. For standards that support a common language, standards adopters include the data users who access and use data supported by the standard. For standards that provide a shared format, the standards adopters include data publishers who publish and share data and data users who access and use data.

Service providers

The people and organisations providing additional services to the standards community are known as vendors, suppliers and providers. Services can include tools, consultancy, implementation, training and support.

Existing tool developers are valuable as implementing or supporting the standard in their tools can provide a major boost to adoption. For example, Hyphen8 implemented the 360Giving standard in their Salesforce tool, giving access to all UK community foundations and providing an easy route to publish their grantmaking data.

Third parties

Outside of the other stakeholder roles we have described, there are a variety of third parties interested in or impacted by standards. For more formally defined standards there is often a strong presence of commercial third parties. For more informal standards there is a strong likelihood of a thriving open source community.

Third parties interested in or impacted by standards include:

- **Consumer / general public**: The people impacted by the standard but unlikely to use it directly or even be aware of it. They may end up benefiting the most from the standard. For example, people using Google Maps for public transport are impacted by GTFS.

- **Interest groups and trade associations**: The people or organisations with financial stakes, influence or other stakes in the impact of the standard on their members or segment. They can be valuable advocates for adoption of the standard if its benefits align with their own. For example Open Government Partnership advocates for the use of open oontracting as it aligns with their goals for more open government.

- **Innovators**: The people or organisations pioneering new and engaging uses of the data shared using the standard. They showcase the possible uses of the data and advocacy for adoption of the standard. They may also be service providers.

- **Specialists**: The people or organisations with expertise in the standards sector or domain. For transit standard GTFS, this community would include transit authorities and transit experts worldwide. Members of the specialist community may also be standards users.

Recommendations

In exploring how standards have been developed and adopted, and their impacts on different communities and sectors, we have learned several lessons.

In our desk research, we found thousands of standards under development, in use or abandoned worldwide.[41] In this report we've summarised some of our key findings from exploring how those standards have been developed and adopted, and the impacts they have created in different communities and sectors.

This section summarises some lessons that have emerged from our desk research.

Use existing standards

Open standards for data are useful when an agreement is needed from more than one party to support data to be produced. The problem needs a repeatable and reusable solution that maximises consistency and clarity. Consider open standards for data to strengthen data infrastructure.

If a standard exists that meets your needs, you aren't yet clear on your needs, or can't convene a community around your standard, creating a new open standard may not be the best option. Focusing on understanding the scope of the problem and potential solutions by commissioning a proof of concept to explore options or working through a discovery phase to investigate the problem and solutions, can lead to better solutions.

Follow the OpenStand principles

To develop an open standard for data, it is worth adopting the five OpenStand principles, ensuring your open standard is developed fairly, transparently and cooperatively. An added advantage of open participation is engaging the community around your open standard before you launch to ensure there is sufficient interest.

Remember that language matters

People use language differently, even in the same organisation. Agreeing early on what concepts are included and being clear on what concepts mean will make your standard easier to understand and adopt. Consider including clear examples to make abstract concepts more concrete.

Consider common features and extensions

Standards are an excellent way of producing consistent data, however each stakeholder may hold or use data slightly differently. As part of stakeholder engagement, it is important to understand the common features as well as where vocabulary, language and data-use diverge.

Consider how the standard will be used, and who will be using it

There are many ways to think about standards – one useful way is how they are used. Will users of the standard be expected to publish data? Will they use the standard as a vocabulary to support publishing data? Is the standard a guide to support

[41] GovEx and Geothink, 'Open Data Standards Directory', http://datastandards.directory

developing a common language so others can publish data? The outputs will impact the type of tools, guidance and support needed by users of the standard.

Choose the right development process

All open standards development processes fall somewhere on a spectrum between formal processes with clear governance and working groups, to informal collaborations using loose guidelines.

The best open standards development process is the one that works for the audience, sector and type of standard under development. Starting from five Open Stand principles, it is useful to consider the best practice that works for your open standard development and its community.

Be clear on purpose

Producing consistent data is an end goal of all open standards for data. Depending on the purpose of the standard, this may be a secondary goal. The primary goal could be to change perceptions or convene stakeholders around a shared problem, level the playing field for participation in a sector, or solve a problem impacting data infrastructure. Clearly articulating the purpose of the open standard provides the basis for engaging the community consistently, brings focus to development of supporting tools and resources, and ensures the standard stays on track.

Know your community

Open standards for data affect a wider community than data users and data publishers; they include the people and organisations that are affected by the standard, including the owner, sponsor and developer of the standard, and third parties. It is worth understanding the known roles in an open standard community and identifying the key stakeholders. This will make engaging the community easier, and ensure you consider their technical, tool, comms and resource needs, including their levels of digital literacy, access to physical and digital spaces and what else might be needed to successfully engage with them.

Consider who is missing

When deciding on technical language, file formats, location and format of resources, and where the community meets, be aware of who is and is not included. Using GitHub as a primary means of handling issues, for example, excludes people who do not use that platform. Convening meetings that require physical presence, especially in relatively expensive locations, exclude others. The needs of the community should influence these decisions rather than the personal preferences of the standards owner or developer.

Develop visible guidance

Having clear and visible description of the standard's governance process and roadmap will increase trust and confidence from the community. These do not have to be long documents; Google's GTFS relies on a short set of guiding principles, written in plain English.

Agree ownership and copyright

Clearly stating who holds the intellectual property and copyright on the standard will help avoid issues such as misuse of branding down the road. Additionally, if the community is invited to contribute to the development of the standard, consider who

retains the intellectual property and copyright on their contributions to avoid future legal blockers.[42]

Develop use cases

Open standards for data support the production of data, so it is important to have some idea of how the data will be used. This partly supports the argument for the standard to exist in the first place and, more importantly, helps the standards developer to understand what is essential to the standard and what is optional and could be excluded. Differentiating between core and optional needs also helps focus resources and prevent bloated, over-specified standards that can be a barrier to adoption. Testing the standard with real-world data use will help refine the standard further and highlight issues early.

[42] Scassa, T. (2015), 'Public transit data through an intellectual property lens: lessons about open data',
http://ir.lawnet.fordham.edu/cgi/viewcontent.cgi?article=2553&context=ulj

Methodology

As part of our broader engagement to explore open standards for data we have:

- surveyed a wide community of people and organisations to ask them how they go about solving problems using data
- interviewed people involved with standards and open standards projects
- facilitated workshops with organisations that develop open standards for data

For this report we focused on carrying out desk research on standards, open standards and open standards for data using:

- recommendations from people working with open standards
- keyword searches in search engines and academic libraries
- widened keyword search, using bibliographies from relevant documents
- case study research on standards that were good examples of their category, type or development process

We analysed the contents of relevant documents listed in the bibliography, looking for themes and patterns around the following research questions:

- What existing research is there on standards development for data?
- Who is interested in, and working on, standards development for data?
- What existing categorisations or classifications for standards are there? (e.g. vocabularies vs data formats)
- How do they describe the process of standards development?
- How do they describe the actors who are involved in standards development?
- What methods have been developed to measure the quality of a standard?
- What methods have been developed to measure standard adoption?
- What existing guidance / recommendations are there about standards development for data?

Appendix 1: Comparing open standards development lifecycles

From research

US Environmental Protection Agency	*Propose → Develop → Review → Approve*
Global Standards Management Process (GSMP)	*Steering → Requirements → Develop → Collateral*
Real-Time Transit Case Study	*Initiate → Develop → Implement → Evolve*
IEEE: Standards Development Lifecycle	*Idea → Approve → Develop → Approve → Publish → Revise* *Idea → Approve → Develop → Approve → Publish → Withdraw → Archive*

From case studies

GTFS Case Study	*Closed alpha → Launch → Closed beta → Live → Community update → Closed revision*
BSI PAS182 Smart city concept model case study	*Idea → Sponsorship → Scoping → Research & generation → Drafting → Steering group review → Review panel consultation → Steering group review → Draft finalisation → PAS publication → Launch*
Brownfield Site Register Open Data Standard case study	*Closed pilot → Planning → Legislation → Workshops & consultation → Launch*

Appendix 2: A brief bibliography

The references and links in this section are not intended to be a comprehensive or extensively-curated bibliography. They represent some interesting and useful sources discovered during desk research for this project. They are grouped by research question. *Note: some links are behind academic paywalls. Editorial notes are in square brackets.*

What existing research is there on standards development for data?

Recommendations from people and organisations working with open standards:

Guidon, Stéphane, McKinney, James, Open Data, Standards and Socrata (Stéphane Guidoin and James McKinney) (2012)

Huijboom, Noor and Tijs Van den Broek. Open data: an international comparison of strategies (2011) [Defining an open standard]

Nicklin, Andrew, Enabling Civic data Standards (2015) by Andrew Nicklin

Palfrey, John Gorham, and Urs Gasser. Interop: The promise and perils of highly interconnected systems. (2012) [Difference b/w quality standards and interoperability standards]

Russell, Andrew L., Open Standards and the Digital Age (2014) [Defining an open standard]

Scassa, Teresa, Public transit data through an intellectual property lens: lessons about open data (2015)

All Transit Agencies In all countries: 1026. With open data: 292. Without open data: 734

BOMOS: Management and Development Model for Open Standards

Dashboard for OD Standards

Data Standards: At the Intersection of Sites, Clinical Research Networks, and Standards Development Initiatives (pg: 399-401)

EU: Common Assessment Method for Standards and Specifications (CAMSS)

Global Standards Management Process

Global Standards Management Process (GSMP) Manual

Gov.UK: How an open standards proposal is assessed

How Standards Are Made – The IEEE-SA Process

How we develop standards

Impact of Social Networking on development of Open Standards

Inside Geothink's Open Data Standards Project: Standards For Improving City Governance (2016)

Intel ® Healthcare IT Standards and the Standards Development Process: Lessons Learned from Health Level 7 (pg: 72-76)

ITU-T Recommendations

Know when your bus is late with live transit updates in Google Maps

Making Open Transportation Data Useful and Accessible: Recommendations for Good Practices in Open Data Standards Management

Open Civic Data Standards in Canada (Rachel Bloom and Renee Sieber)

Open Data Standards by Azavea

OpenStand 5 Principles

Open Standards, Open Source, And Open Innovation: Harnessing The Benefits of Openness

Open Standards for Sustainable Development

Open Standards vs Open Data Standards: Trends

Pioneering Open Data Standards: The GTFS Story

Real-Time Transit Passenger Information: A Case Study In Standards Development

The Standards Development Lifecycle

US EPA Data Standards Development (2010)

What existing categorisations or classifications for standards are there (e.g. vocabularies vs data formats)?

BOMOS: Management and Development Model for Open Standards

Data Standards: At the Intersection of Sites, Clinical Research Networks, and Standards Development Initiatives

Enabling Civic Data Standards

Gov.UK: How an open standards proposal is assessed

HL7

Making Open Transportation Data Useful and Accessible

Open Data, Standards and Socrata (Stéphane Guidoin and James McKinney)

Open Data Standards by Azavea

Real-Time Transit Passenger Information: A Case Study In Standards Development

US EPA Data Standards Development

White Paper on OD Standards

How do they describe the actors who are involved in standards development?

BOMOS: Management and Development Model for Open Standards

> Working Group, Semantic Standardisation Organisation, Standards Developing Organisations (SDO), Working Group

Data Standards: At the Intersection of Sites, Clinical Research Networks, and Standards Development Initiatives

> Working Group, Standards Development Organisation, Stakeholder, Clinical Research Community

Global Standards Management Process

> Working Group, Direct Participant, Indirect Participant, Governance Group, Voting Member, Non-Voting Member, GSMP Community, General Public

Gov.UK: How an open standards proposal is assessed

> Providers, Open Source Providers, Proprietary Providers, Standardisation Organisation, Vendors, Suppliers, Interest Group, Maintenance Organisation, Standards Body, Stakeholder Group

[How Standards Are Made – The IEEE-SA Process]

Working Group, Committee, Governance Board, Standards Development Organization (SDO)

[Impact of Social Networking on development of Open Standards]

Standard Architect, Technical Committee, Committee Member

[Intel ® Healthcare IT Standards and the Standards Development Process]

Standard Developing Organization (SDO), Members, Volunteer Members, Working Group

[Making Open Transportation Data Useful and Accessible: Recommendations for Good Practices in Open Data Standards Management]

Standards Development Organization

[Open Civic Data Standards in Canada (Rachel Bloom and Renee Sieber)]

Adopter, Potential Adopter, Stakeholder, Benefactor, Publisher

[Open Data, Standards and Socrata (Stéphane Guidoin and James McKinney)]

Author, Original Author, Third-party, Standards Body, Open Data Innovator, Working Group, Publisher, Consumer

[OpenStand 5 Principles]

Standards Organization, Participant

[Open Standards, Open Source, And Open Innovation: Harnessing The Benefits of Openness]

Participant, Supplier, Customer, Working Group

[Real-Time Transit Passenger Information: A Case Study In Standards Development]

Creators, Users, Implementers, Standards setting organizations (SSO), Standards Developing Organizations (SDO), Open Source Software (OSS) Community, Trade Association, Technology Provider, Incumbent Vendor, Vendor challenger, Complement Provider

[US EPA Data Standards Development]

Designee, Chief Information Officer (CIO), Senior Information Official (SIO), Information Management Officer (IMO), Information Resources Management Branch Chief (IRM BC), Data Standards Branch (DSB), Quality Information Council

What methods have been developed to measure the quality of a standard?

BOMOS: Management and development model for open standards

Proposed based on: Effectiveness, reliability and practicability

Global Standards Management Process (GSMP) Manual

Appendix: Piloting of GS1 Standards and GS1 Guidelines – details that an testing and evaluation is done but not how

Gov.UK: How an open standards proposal is assessed

47 questions based on CAMSS

Making open transportation data useful and accessible

Market share, compatibility, rigor and user satisfaction – source or basis not stated

Open Civic Data Standards in Canada (Rachel Bloom and Renee Sieber)

Quality metrics of domain-specific open data standards – based on Dublin Core metadata element set

Open data standards by Azavea

Location-based, Published standard, Machine-readable, Adoption – less a quality measure, more an acceptance criteria

Real-time transit passenger information: a case study in standards development

Framework of 10 requirements based on Krechmer's ten requirements of open standards

What methods have been developed to measure standard adoption?

Dashboard for open data standards

Inventory of open data standards – details “level of use by governments” but not methodology

Adoption of open data standards by cities – evaluates adoption across cities

What existing guidance and recommendations are there about standards development for data?

[Making open transportation data useful and accessible]

Based on methodology for evaluation (market share, compatibility, rigor and user satisfaction – source or basis not stated)

[Open standards, open source, and open innovation]

Mainly around policy: policy recommendations regarding open standards

[Real-time transit passenger information: a case study in standards development]

Specific recommendations around transit data standards – Chapter 5: Recommendations