BUILDING
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Location Standards for Utilities in New Zealand

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Quake Centre
Delivering Industry Solutions

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Executive Summary

> *"Everything is related to everything else, but near things are more related than distant things."*
>
> *Waldo Tobler - First Law of Geography*

The purpose of this paper, compiled by OpenWork Ltd (OWL) on behalf of Quake Centre, is to support and further progress the implementation of a robust standard that allows the sharing of information between utilities and transportation sectors based on a common understanding of location. Such a capability is envisioned to support systems that are more efficient, cost effective, resilient and provide a greater level of safety. This reports reviews and augments the work done by e-Spatial in their recent report (e-Spatial, 2019). These findings are further supplemented by materials gathered in the two AMDS - Location Standards Workshops in Wellington held in May and October 2019. Further research and conversations with experts augment these findings. One point of difference is that, while e-Spatial, rightfully for their mandate, donned the perspective of the NZ Transport Agency and Road Efficiency Group Asset Data Management System (NZTA ADMS), the primary focus of this paper is the underground utilities (3 Waters) perspective. This difference helps ensure solutions that are more useful to more parties.

The top recommendation of this paper is to hold a workshop which would review the user stories compiled by e-Spatial and survey results from Openwork Ltd, so as to better understand and prioritise the common challenges and impediments faced by the multiple parties that are involved and who would benefit from this effort. We recommend that this workshop also be used to initiate a governance process for this work and define its essential architecture (in line with international best practice), while gathering terms that would become part of our standardised shared vocabulary.

1 Introduction

On 30 October 2019 OpenWork Ltd (OWL) hosted the second AMDS-Location Standards Workshop in Wellington (hereafter referred to as the 30 October workshop) on behalf of Quake Centre and the New Zealand Transport Authority (NZTA). This workshop, together with the e-Spatial report (e-Spatial, 2019), the subsequent survey conducted by OWL, and augmented by further research and conversations with experts, provide the foundation for this report. The perspective presented in this report places particular focus on the applicability of the recommendations from the e-Spatial report to underground utilities, particularly ‘3 Waters’ infrastructure. It also focuses on potential barriers to implementation of chosen solutions which may be faced by participating organisations. Consultation with appropriate international standards bodies was included to understand the alignment with international best practice as well as to support future development trends. The desired outcome is the ability to share location data between the NZTA AMDS, 3 Waters and other domains easily via common location data standards.

This report addresses concerns about how location standards should be adopted and applied by all participating organisations. The advice has been developed by OWL based on our considerable experience in standards development and implementation, and knowledge of future trends.

Considerations include:

1. **Implementability**

   Selected standards must be useful to those that need them and avoid common and identified barriers.

2. **Scalability**

   The standards should be useful to those at multiple levels of technical ability, maturity and size of data holdings.

3. **Minimal harm to business as usual**

   Internal systems have evolved the way they have usually for very good reasons. Chosen standards should operate at the interchange level and focus first on interoperability rather than integration.

4. **Sustainability**

   Sound modelling and good governance are critical factors that contribute to solution longevity. Compatibility with emergent technology is desired.

5. **Shared vocabularies**

   These are central to a good standard as they support the desired interoperability and communicability both within and across sectors.

This list generally leads to well modelled, flexible standards with built in mechanisms to support extension and well managed change. Such data standards are usually best implemented as interchange standards that provide a 'shared' version of the data while preserving the internal data structures used by agencies to continue to address local business requirements. To support the desire for data that can be shared for multiple purposes, we look to flexibility in such standards to support sub-domain governance where needed. While it is their very stability that makes standards useful, it is important that changes can occur where and when needed so as to avoid obsolescence. This requires that the standards and their communities be well governed.

It is our belief that that the most important part of the standards process is the development of a community that creates the will and the ability to share resources. Upon this foundation greater things may be built.

1.1 FAIR principles

In this work we support the F.A.I.R. values in making data (Go Fair, n.d.):

Findable

The first step in (re)using data is to find them. Metadata and data should be easy to find for both humans and computers. Machine-readable metadata are essential for automatic discovery of datasets and services, so this is an essential component of the "FAIRification" process.

Accessible

Once the user finds the required data, she/he needs to know how they can be accessed, possibly including authentication and authorisation.

Interoperable

The data usually need to be integrated with other data. In addition, the data need to interoperate with applications or workflows for analysis, storage and processing.

Reusable

The ultimate goal of FAIR is to optimise the reuse of data. To achieve this, metadata and data should be well-described so that they can be replicated and/or combined in different settings.

2 Background

The aim of the paper is to progress towards the desired outcomes of the October 2019 AMDS workshop:

> The establishment of nationally agreed location standard(s) for the exchange of horizontal infrastructure (transport and utility) asset data to support cross domain interoperability.

Cochrane, B. Murcott, R. & Preston, G. personal notes and recordings, 30 October 2019

It has further been determined that such standard(s) will meet the following requirements wherever possible:

1. They will be based on and contribute to international standards, consensus and best practice.
2. They will be Open as per the DIA definition of 'open standards'.
3. Where necessary, they will be properly profiled to suit NZ needs.
4. Proper governance will be provided by the community of users.
5. They will be tested through an international interoperability experiment.

In this section we provide detail as to what this means.

2.1 Location

As location is our focus, a brief discussion of our meaning is useful. For the purpose of this report we will adopt the Austroads definition:

> Location is defined as a virtual object that is temporal, graphical and model-independent. The virtual location object can be a point, line, path or area, representing a physical place … that may be identified in any given model by a suitable location reference.

Austroads, 2018[a]

What has become clear through our work is that it is important that the chosen location standard(s) be able to support linking otherwise disparate information. To exchange information between different domains and in a ubiquitous way, a harmonised location standard that supports interoperability is useful, desirable and needed. Such a standard should allow one to begin to answer questions such as "Who is responsible for maintenance of the drain next to my railroad track at this specified location?" (Cochrane, et al., 2019). Location is key in identification of such a feature. Once identified, further information about that real-world feature can more easily be obtained.

2.1.1 Three types of Location Reference Method (LRM)

In adopting such a definition, we acknowledge that there is no one best approach to the capture of location information that best suits all purposes. We can summarise the dominant location referencing methods into three families (Figure 1). Each have their strengths and strong user communities. Each family has its purpose. None should be viewed as a lesser approach to capturing location information.

- Family 1: Topological (Linear/Network) - Linear Referencing
- Family 2: Geometric (Model Coordinates) - CAD & BIM
- Family 3: Geospatial (Real World Coordinates) - GIS & Mapping

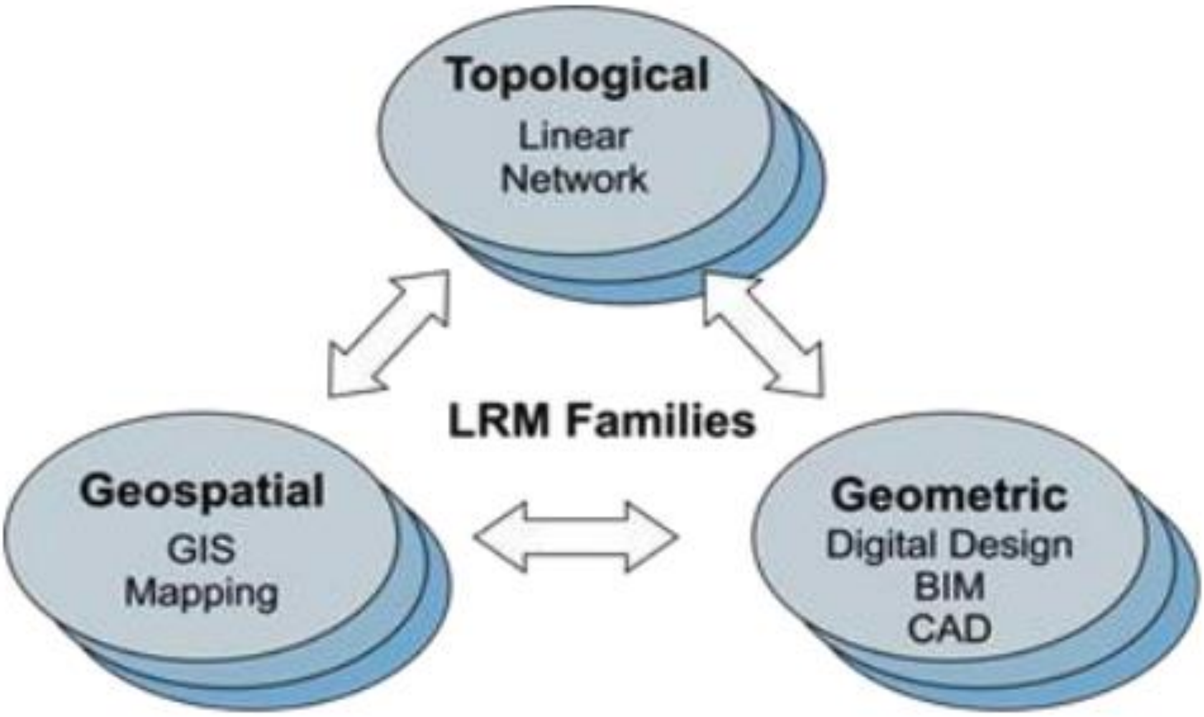


Figure 1: Three location referencing method families (Austraroads)

Of these, Geospatial LRMs are the most suitable to our requirements. However, both topological and geometric LRMs are in heavy use by our stakeholders and must be taken into consideration. At a minimum, this would suggest supporting the ability to convert data between these LRMs as a component of this work.

These LRM families are discussed in more detail below.

2.2 Standards

To understand the work this entails, a discussion of our standards framework is useful. ISO, the International Organization for Standardization, defines a standard as:

> … a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose.
>
> International Organization for Standardization, n.d.

The purpose of standards in our context is to improve the ability to share information. Sharing information is also the very definition of communication. Language is the term we use to describe how we communicate. Standards provide the vocabulary and grammar by which we share information. Vocabularies and grammars can be ambiguous. With standards we hope to greatly reduce this ambiguity and thereby better ensure fitness to purpose.

There are numerous standards bodies, local, regional and international. The most important in the geospatial realm are ISO TC211 and the Open Geospatial Consortium (OGC) (e-Spatial, 2019). These are widely recognised international bodies that meet the criteria stated in Background Item 1 above. New Zealand holds full membership in ISO TC211 and has many members in OGC. Other relevant standards bodies to consider for this work include:

- ISO TC251 - Asset management standards
  - Responsible for the ISO 55000 series of standards
  - Widespread adoption in utilities, transport, mining, process and manufacturing
  - New Zealand holds observer status (International Organization for Standardization, n.d.[b]).

- ISO TC59 SC13 - Organisation and digitisation of information about buildings and civil engineering works, including building information modelling (BIM) (International Organization for Standardization, n.d.[a])
  - This is a key standards body to support the integration of geometric and geospatial LRMs.
  - Providers of IFC codes
  - No New Zealand participation - Likely not reflected in Standards NZ catalogue.

- Building Smart International - buildingSMART, bSI
  - Like OGC but for the built asset industry, infrastructure and buildings
  - Open, neutral and international not-for-profit organisation
  - BuildingSMART Australasia is the regional chapter - Austroads primary partner.

Standards come in many flavours. What we are concerned with in our work are data interchange standards and perhaps once these are sorted, web service standards by which we share these data.

2.2.1 Data interchange standards

Data interchange (exchange) standards are a type of data standard that focuses on the exchange of information between system agnostic organisations. This type of standard is the primary focus of our work. The advantage of specifying an interchange standard as opposed to a full data standard, is that it allows organisations to store their data as they like. Adhering to such a standard means they can continue business as usual internally while exposing to others this same information structured in the agreed standard. To accomplish this, extract, transform and load (ETL) tools, such as The Feature Manipulation Engine (FME) from Safe Software (Safe Software, n.d.) are often employed.

2.2.2 Web service standards

Once an interchange standard is in place, agreement on supported web service standards is commonly necessary. An agreed service standard allows data sharing participants to know how to retrieve and share such data. The OGC Web Feature Service (WFS) is one commonly used service standard. Future testing will determine the need for web service standards in our work.

2.3 Open standards

An authoritative definition for ‘open’ in context of standards is hard to come by. For this we defer to Department of Internal Affairs (DIA). But even there, the definition is less than complete. The Government Enterprise Architecture for NZ (GEA-NZ) webpage states under Digital Standards Principle 2 (Open and transparent) that “Adopted standards should be openly published, developed in a transparent way, freely available, have an acceptable level of use, and be regularly maintained.” (Department of Internal Affairs, n.d.).

The 2008 version of the preceding DIA e-Government Interoperability Framework (e-GIF) document contained a more detailed discussion:

> While a universally agreed definition of 'open standards' is unlikely to be resolved in the near future, the e-GIF accepts that a definition of "open standards" needs to recognise a continuum that ranges from closed to open, and encompasses varying degrees of 'openness'. To guide readers in this respect, the e-GIF endorses 'open standards' that exhibit the following properties:
>
> - Be accessible to everyone free of charge: no discrimination between users, and no payment or other considerations should be required as a condition to use the standard.
> - Remain accessible to everyone free of charge: owners should renounce their options, if any, to limit access to the standard at a later date.
> - Be documented in all its details: all aspects of the standard should be transparent and documented, and both access to and use of the documentation should be free.
>
> The e-GIF performs the same function in e-government as the Road Code does on the highways. Driving would be excessively costly, inefficient, and ineffective if road rules had to be agreed each time one vehicle encountered another.

DIA, 2008

Under some definitions of 'open', ISO standards may not be considered due to the requirement of monetary payment to access the full standards document (ISO, n.d.). But because the standard is equally accessible to all and no royalties are charged for their use, ISO standards arguably do fit under the definition of open in most cases, such as the e-GIF definition above. It is less clear that it would be considered open under the GEA-NZ framework definition. An acceptable definition of 'open' would be helpful. It is hoped that DIA will provide this. If not, we may need to supply our own. A good starting point on this topic can be found on the Opensource website (opensource.com, n.d.).

DIA is in the process of reviewing advice in this area. It would be useful if our work could contribute to this. The current DIA standards guidance (DIA, n.d.2) does not emphasise the term 'open' but the principles are the same.

2.4 Profiles

It is unlikely that OGC and ISO TC211 standards will suit our needs 'out of the box'. It has been acknowledged by participating stakeholders that adopted standards will need to be made fit to purpose according to our requirements. As such, there is likely to be the need to create local amendments. This process is known as profiling. The standard ISO 19106:2004 Geographic information – Profiles (International Organization for

Standardization, 2004) is designed to support and guide this process. Alterations to suit identified needs can be made in many cases without altering or violating the standard.

It includes the following definition of 'profile':

> …[a] set of one or more base standards or subsets of base standards, and, where applicable, the identification of chosen clauses, classes, options and parameters of those base standards, that are necessary for accomplishing a particular function. (International Organization for Standardization, 2018[a])

And includes the following note: "A profile is derived from base standards so that by definition, conformance to a profile is conformance to the base standards from which it is derived." (International Organization for Standardization, 2018[a]).

This definition and note are in alignment with the location standards needs as agreed upon at the 30 October workshop (Cochrane et.al, 2019). They allow us to adopt elements from multiple parent standards in the creation of a conforming profile.

One area where profiling often occurs is in the development of specific controlled vocabularies and taxonomies to support a domain or community's needs. The transport sector vocabularies may require some additional terms that the 3 Waters sector does not and vice versa. As long as this does not impact on required interoperability, it can be allowed through profiling. Profiles can also add specificity to a standard to suit a community. For example, in our case, this could be expressed as a requirement to use New Zealand Transverse Mercator (NZTM) coordinate values as opposed to those of any other Coordinate Reference System (CRS).

Profiles allow a community to conform with an international standard in a particular way that reflects the particular needs of the community. Two well-known examples of this in our region are the Australian and New Zealand Land Information Council (ANZLIC) Metadata Profile of ISO 19115:2003 (ANZLIC, n.d.) and the New Zealand Profile of ISO 19160-1:2015 Addressing Part 1 (Land Information NZ, n.d.).

Risks of Profiles

A note of caution should be added here. Implementation of a profile can lead to the creation technical debt. For example, when the standard ISO 19115 was updated in 2014, ANZLIC decided to retire the ANZLIC profile and adopt the new standard without modification. This was, in large part, to avoid the cost of maintenance. Part of this cost was the difficulty we faced as a community in getting vendors to support the ANZLIC profile. It should be noted that reliance on the international standard did not remove the need for the community to form some governance in support of implementing the new standard in our region. The ANZLIC Metadata Working Group was reformed in 2018 after being dismissed in 2015 alongside the decision to use ISO 19115-1 and retire the ANZLIC Profile. It was found that inconsistency of implementation necessitated a body that could provide guidance. While this group has avoided the creation of an official Profile, it does provide a forum to reach agreement on the common use of the standard by providing ongoing governance, best practice, instruction and guidance to the community.

2.5 Governance

> *"Interoperability is not hard, people are hard."*
>
> *Anonymous (Cochrane et al., 2019)*

Standards are only useful in the long term if there exists a dedicated community empowered to maintain them. Interoperability standards only work if a community exists which desires to share information in an ongoing fashion. Governance in our context is a stepwise process of working towards more efficient adoption, implementation and use of open standards.

Some aspects of governance can be gleaned from the definitions of open standards discussed above. The Organization for the Advancement of Structured Information Standards (OASIS) definition governance rules require that open standards:

- be created by domain experts
- be developed under open process
- have allowed anyone affected by the standard to contribute to the development of it. (Organization for the Advancement of Structured Information Standards, n.d.)

Above all, business objectives of the community must be addressed through the use of the standard. To ensure this, agreements, rules and processes need to be created and implemented which assure all stakeholders have a seat at the table, and the proper changes can be made when necessary without damaging existing systems built on this standard.

Further governance advice will be included in the recommendations section of this report.

2.6 International interoperability testing

Establishment of agreed location standards that are useful and sustainable requires robust testing. That this testing be done in an international context enhances their utility and sustainability. At the 30 October workshop it was agreed that a sensible way to progress would be via an Open Geospatial Consortium (OGC) Interoperability Experiment (IE). (Cochrane et al., 2019)

2.6.1 What is an OGC IE?

Interoperability experiments are described by the OGC as:

> … brief, low-overhead, formally structured and approved initiatives led and executed by OGC members to achieve specific technical objectives that further the OGC Technical Baseline.

OGC Innovation Programme, n.d.

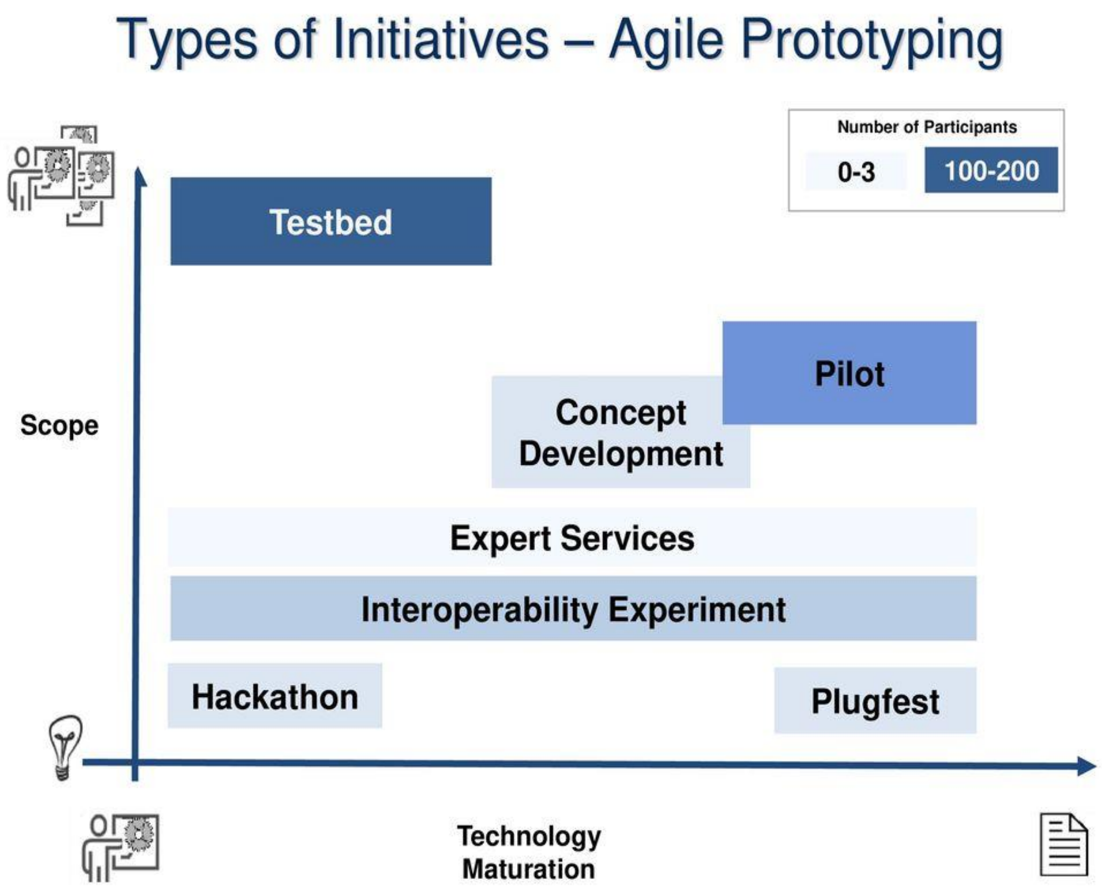


Figure 2: OGC Innovation Program initiatives

They are an initiative under the OGC Innovation Program (OGC IP):

> The OGC Innovation Program provides a collaborative agile process for solving geospatial challenges. Organizations (sponsors and technology implementers) come together to solve problems, produce prototypes, develop demonstrations, provide best practices, and advance the future of standards. Since 1999 more than 120 initiatives have been taking place from in-kind interoperability experiments run by a working group to multi-million-dollar testbeds with hundreds of participants.
>
> OGC Innovation Programme, n.d.

Governed by a set of proven policies, processes and procedures, the OGC IP initiatives fall under one of the following categories: Testbeds, Pilots, Plugfest, OGC Engineering Services, Interoperability Experiments, and Concept Development. It is our opinion that, due to the low cost, flexible in implementation, and the desire not to alter existing standards, an interoperability experiment is the best fit to our needs.

Local New Zealand experience has proven the value of such an approach. OGC oversight ensures that the experiment is in line with and contributes to existing international best practice and standards. In addition, discovery of and access to others internationally who are endeavouring to solve similar issues is provided. This has allowed access to international expertise to better solve common problems. The return on investment has proven to be very high. OGC figures estimate an average return on investment of 3.5x.

It should be noted that OGC membership by one or more participating parties will be required, but this is not a significant cost, financial or otherwise. While the value of working with international experts addressing like problems is significant for progressing and sustaining our work, it does mean compromises may need to be made to reach consensus amongst a larger community. Preliminary enquiries by OWL suggest that a variety of members of the OGC may be interested in an IE that includes the ability to share location data between underground utility and transportation sectors.

Relevant OGC initiatives are discussed later in this document.

3 e-Spatial report review

> *"If you want to go fast, go alone. If you want to go far, go together."*
>
> *African Proverb*

Our review broadly concurs with all the major findings and recommendations in the e-Spatial report (e-Spatial, 2019). But while the e-Spatial report's primary focus was on the needs for location standards to support NZTA asset data management system (ADMS) needs with a secondary concern of supporting other infrastructure data management systems, especially 3 Waters, our view is somewhat reversed. We focused more on underground infrastructure - 3 Waters in particular - and the broader community, including the NZTA ADMS and others as cited in the e-Spatial report. With this in mind we wish to share some alternative views as to the nature and relationship between the options presented in the e-Spatial report.

We found the e-Spatial report to be sound with a number of strengths. We also note a few potential issues.

Strengths

- Personas well targeted
- Software /technology agnostic
- Decision-making process well-reasoned and illustrated
- Strong engagement with stakeholders
- Large collection of useful user stories

Issues

- Limited discussion on geometric Location Reference Methods (BIM and CAD)
- Limited discussion on the relationships between the standards reviewed and how they may coexist
- User Story analysis is incomplete
- Standards development is treated as a sprint instead of a long march
- Governance not adequately covered.

3.1 Process

The approach that e-Spatial has been directed to follow closely resembles the open source software development process. Through a series of sprints, accomplishments can be gained quickly. In contrast to software, standards work must needs be collaborative and open to more compromise if it is to be effective, accepted and sustainable. This may require a slower approach so as to bring as many stakeholders along as possible.

Infobox

How do standards collaborations differ from open source collaborations'?

Standards and open source projects are different collaborations. They're different economic tools in a marketplace with different goals, outcomes, and processes. As Stephen Walli explains:

1. Standards take longer to develop and change. Whereas open source projects can develop quickly, standards encourage multiple implementations and tend to enter a market with some maturity and competition. Standards and specifications don't change quickly, so they are developed with the expectation that they'll need to last for longer periods of time. For example, moving from HTML1.0 to HTML5 standard took about 18 years, and we've had TCP since 1981 with few changes.

2. Standards are consensus-based compromises. Open source projects are driven by contribution and meritocracy.

3. Standards define useful predictable boundaries. Well-run open source projects are the building blocks of rich, varied ecosystems.

From https://opensource.com/resources/what-are-open-standards

3.2 Reviewed standards

The e-Spatial report quite easily reads as providing three independent options for location standards:

1. Austroads Data Standard for Road Management and Investment in Australia and New Zealand: Version 2 (Austroad standard v2)
2. Datex2 together with OpenLR
3. ISO TC211 and OGC.

However, it should be emphasised that the reality is not quite so simple. There exist strong interrelations between these presented options. Clear delineations are not possible. They build on each other while viewing the domain from their independent perspectives.

3.2.1 Austroads

Who are Austroads, the organisation?

> Austroads is the peak organisation of Australasian road transport and traffic agencies.
>
> Austroads members are collectively responsible for the management of over 900,000 kilometres of roads valued at more than $250 billion representing the single largest community asset in Australia and New Zealand.
>
> Austroads' purpose is to support our member organisations to deliver an improved Australasian road transport network. One that meets the future needs of the community, industry and economy. A road network that is safer for all users and provides vital and reliable connections to place and people. A network that uses resources wisely and is mindful of its impact on the environment.

Austroads, n.d.

It is our opinion that in our work the role of Austroads, the organisation more than the standard, warrants further discussion. While the technical merits of the Austroads Standard v2 (Austroads, 2018[a]) do not suit our needs to support the cross-domain sharing of spatial information, Austroads is after all the peak organisation of Australasian road transport and traffic agencies. So, this community needs to be included in these discussions as a stakeholder. Not to do so would be contrary to the standards collaboration process. Location standards chosen by our group should be shared with Austroads as a stakeholder. Not to do so risks the development of competing solutions and reduced interoperability (Figure 3).

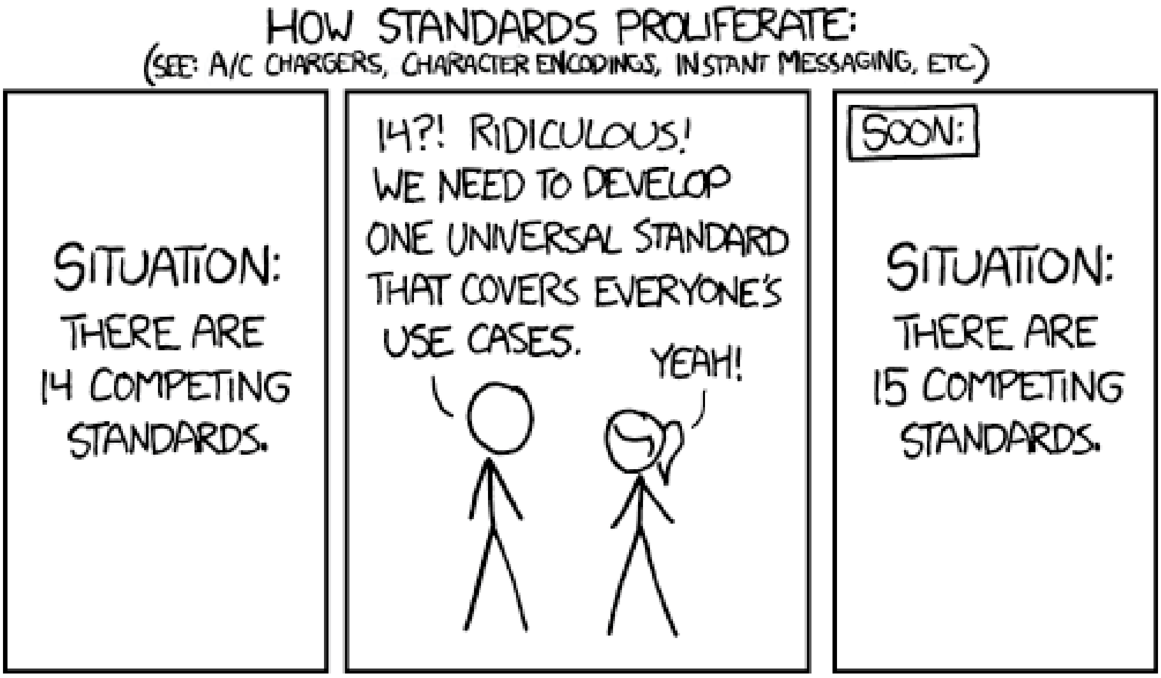


Figure 3: XKCD 927 - CC BY-NC 2.5

The Austroads Standard v2, as reviewed in the e-Spatial report (e-Spatial, 2019), is designed to work at the application level to serve routing and asset management needs for road networks. It envisions an architecture with a data aggregator that collects and translates these data. It does not assume that providers capture or even share their data all in the same format. Location standards are only partially addressed. Such details as these are left to their various data providers. Data shared in this standard does support a number of useful asset management applications - particularly road maintenance - but the determination of co-location with assets from other domains is not one of them.

Due to their road asset management focus, Austroad Standard v2 recommends Linear Referencing as the primary location system (Level 1). While Levels 2 and 3 address coordinate values in two- and three-dimensions respectively, they say little about how these coordinates should be captured or whether they use geometric or geospatial LRMs. Therefore, the ability of this Standard to support our desired outcomes is limited.

LOCATION REFERENCING (L)		
L1	L2	L3
Non Graphical Asset Register • *Network 1D spatially located.* • *Asset location referenced by centreline distance/side/offset and known locations.*	2D Digital and Graphical Representation • *Network 2D spatially located.* • *Assets spatially referenced in a 2D context.*	3D Digital and Graphical Representation • *Network 3D spatially located.* • *Assets spatially referenced in a 3D context.*

Figure 4: LRM Families (Austraroads)

Two recent Austroads reports provide a better guide to reconciling differences between LRMs - particularly geometric and geospatial (Austroads, 2018, Austroads, 2018[b]). Linear and Network LRMs are also addressed. In addition, the latter document addresses Datex2 and OpenLR standards and their applicability. It also contains numerous references to ISO (including 191xx series) and OGC (especially LandInfra) standards (discussed below) (Open Geospatial Consortium, n.d.[d])

3.2.2 Datex2 and OpenLR

On first glance it would appear that Datex2 and OpenLR are excellent choices for our situation - at least to address NZTA ADMS requirements. They are open standards with reference implementations that are designed to work with roading infrastructure. But e-Spatial were right to disregard this choice. For, while suitable to routing and asset management, they are not designed to be standards by which relation of objects from different domains can be determined. The precision and accuracy of the locations are also less than desired.

As noted in the e-Spatial report, the current version of Datex2 uses OpenLR to capture location information (e-Spatial, 2019). For the purposes of this work we can limit our discussion to OpenLR.

OpenLR is an LRM which:

> … assumes a map on the sender side from which the location is encoded and a map on the receiver side in which the decoded location is found back. An obvious way of Location Referencing is using geographic coordinates. One important disadvantage of using coordinates is that it assumes identical maps at both sides of the communication chain which often is not the case. As a consequence, the decoded location may not be found back in the receiver map or decoding (e.g. map-matching) may be inaccurate or ambiguous. OpenLR™ is a method for

> location referencing which does not have this disadvantage. It accommodates requirements of communication of location between systems which have dissimilar maps. OpenLR™ is communication channel independent. It takes bandwidth requirements into account in the sense that OpenLR™ requires minimal bandwidth. (Open LR, n.d., p. 14)

As such it is more concerned with network location rather than geospatial accuracy. It was:

> … designed for the use case of transferring traffic information from a centre to in-vehicle systems, built-in or used as an add-on (PND, Smart Phone). The information transferred can consist of the current traffic situation at a certain location, a traffic forecast or special alerts. The corresponding locations are roads, a list of connected roads, points of interest, or areas. (Open LR, n.d., p. 14)

While OpenLR does specify recording location to geospatial coordinates, it mandates the use of an unspecified version of the World Geodetic System 1984 (WGS84) coordinate reference system to 5 decimal degrees as is common in web mapping applications such as Google Maps. This provides an accuracy of at best approximately one metre at the equator (less as one moves north or south). Due to issues such as continental drift (which can change latitude, longitude coordinate placement by up to 1.8 metres in 20 years) WGS84 has gone through several revisions since it was first adopted. Since no specific version of WGS84 is mandated, distances cannot be measured more accurately than 2.5 metres with this approach. Being tied to an unspecified version of WGS84, this positional accuracy will continue to degrade over time.

OpenLR references no OGC or ISO standards. By specifying WGS84 coordinate pairs in reverse order (Lon, Lat) the standard violates geodetic standard ISO 6709 (International Organization for Standardization, 2008). This alternate coordinate order, while in our opinion incorrect (because it confuses spherical coordinates with planer) is not uncommon. This is consistent with the GeoJSON method of capturing coordinate pairs (which are also tied to an unspecified version of WGS84). If one is only concerned with streets and networking, OpenLR may suit. For our needs OpenLR is a poor fit.

3.2.3 ISO TC211 and OGC

We concur with the decision to focus on ISO TC211 and OGC as the basis for our location standard(s). These organisations provide mature well managed standards that are relatively future proof. Solutions based on these standards have the best potential to interoperate even if their profiles differ.

However, because of the foundational nature of these standards, and the lack of a standard in their suites specifically suited to our community of users, the establishment of a Location Standard for Utilities and Transport based on ISO TC211 and OGC will require more work than implementing a standard like OpenLR. Considering that no other standard has been or is likely to be identified that suits our requirements ‘out of the box’, we concur with e-Spatial that the establishment of a location standard based on ISO TC211 and OGC is the right approach.

3.3 Location reference methods (LRM)

The e-Spatial report (e-Spatial, 2019) well addresses different options in location standards in the domain of road asset data management. In this section we would like to discuss location standards at a more abstract level in order to better understand the implications of our choices.

Let’s start with a review of the three main families of Location Reference Methods (LRM). Each has its strengths and strong user communities, and each has its purpose. None should be viewed as a lesser approach to capturing location information:

- Family 1: Topological (Linear/Network) - Linear Referencing
- Family 2: Geometric (Model Coordinates) - BIM and CAD
- Family 3: Geospatial (Real World Coordinates) - GIS.

3.3.1 Linear and Network referencing (Topological)

There are two groups of Topological LRMs:

- Linear referencing (discrete linear elements)
- Network referencing (a topologically connected routable network of linear elements).

Linear and Network reference systems provide advantages for viewing and understanding network logic. The international standard ISO 19148:2012 (International Organization for Standardization, 2012.) is the formal expression of this approach and states: “…[I]n some situations, having a linearly referenced location along a known linear element is more advantageous than knowing its spatial position” (Kenley, Yeo & Harfield, 2019). This approach is in many cases arguably more friendly to human cognition. Like an address, the references are self-contained and do not require a decoder to determine the location shared. This system simplifies location to internal references to its own system without concern to the outside world. This can be advantageous to fixed or physical asset register (known as FAR and PAR respectively) management as well as physical tasks such as pavement management and traffic routing. The perspective here is that of the network logic. Linear referencing is the default, Level 1, LRM in the Austroads standard. (Austroads, 2018[a])

Dynamic segmentation, as discussed in the e-Spatial report (e-Spatial, 2019), provides an attractive way of implementing a linear referencing system in a GIS that introduces flexibility and reduces the need to break arcs. Thus, it provides a method of making geospatial information more compatible with known linear referencing systems. These advantages are well described in the e-Spatial report.

3.3.2 Geometric referencing

Geometric reference systems are most commonly used by the design and engineering community. Think CAD (Computer Aided Design) and BIM (Building Information Modelling) systems as well as digital twins. Typically, they include digital design, whether 2D or 3D models. These approaches view their objects in local model coordinates centred on the object being designed, modelled or built. These coordinates are most commonly not tied to an earth location. A pump in a fresh water supply system will have been designed in CAD but not tied to a real-world location until perhaps when it is placed in the network. The same is true for buildings and other structures. Geometric reference systems are used heavily in the utility and transport sector. Geometric LRMs provide the logic that is commonly used by CAD and BIM software packages such as 12D, Autocad, Bentley, and Rivet to encode location.

3.3.3 Geospatial referencing

Finally, we have Geospatial Location Reference Methods. Think coordinate locations used in mapping and GIS. This is the only LRM family suitable for allowing location of real-world objects collected by different domains to be referenced together. To accomplish this, geospatial LRMs use coordinate systems based on mathematical models of the Earth itself. These LRMs can be thought of as Earth centric in contrast to object centric geometric LRMs or network centric linear LRMs. Because of the ability of geospatial reference models to spatially relate things independent of the subject matter, this is naturally the system to support our primary use case of domain agnostic systems for exchanging location information. The e-Spatial report (e-Spatial, 2019) well covers the advantages of geospatial referencing.

3.4 Conversion

Because of the ability to provide project agnostic locations by which data from different domains can be related, the e-Spatial report properly identifies geospatial referencing as the desired primary method for sharing location information. But important business reasons exist behind stakeholder decisions to use linear, network or geometric referencing for internal processes. These provide solutions to business needs which geospatial referencing may not fully address. Therefore, conversion between these and our geospatial interchange standards must continue to be supported. Support for conversion between these LRMs becomes a major concern which is often addressed in at least the short term through the use of ETL middleware such as Safe Software FME.

3.4.1 Geospatial to linear referencing

Conversion from a linear referenced location to geospatial is commonly achieved by attaching coordinate values to the objects in a linear reference system. It is more difficult to do the reverse - move from a geospatial reference to a location in a linear reference system - because the geospatial location values are inherently less tied to the objects identified. The method commonly used involves employing a GIS application to find the nearest candidate object to a geospatial location description. Identifying the particular referenced object generally requires some human judgement. This is exacerbated if the geospatial references are of low quality, do not consider a particular coordinate system, or are not adequately specified to a system. It is useful to standardise and document the coordinate reference system to be used and ensure it is tied to well-known locations. Work underway at LINZ on Utility Location Standards (ULS) will aid in this by specifying NZGD 2000 as the coordinate system and providing support to tie location to the LINZ continuously operating reference stations (CORS) common frame network to minimise differences in coordinate values due to mechanical, time and other issues.

3.4.2 BIM GIS Conversion

Translating data between geometric (BIM) and geospatial (GIS) is a central issue in our domains. For example, plans and as-built drawings are typically captured in CAD but are usually stored in local authority systems in GIS formats. The OGC LandInfra conceptual model and other initiatives such as ISO 19166 (see e-Spatial, 2019) focus on the difficulties of sharing data between the two systems. While the e-Spatial report mentions standards such as ISO 19166 that address this issue, it is our opinion that the e-Spatial report did not adequately address interoperability issues related to locations stored in geometric reference systems. A real-world New Zealand example is discussed later in this document (Reference - Plugfest and Testbed 11 addressed conversion issues of As-Builts to city GIS from SCIRT CAD.)

3.5 Standards not reviewed

On the basis of the user stories supplied in the e-Spatial report (e-Spatial, 2019) and comments gathered at the 30 October workshop (Cochrane et al., 2019), we recommend that the review include a number of additional ISO TC211 and OGC standards. The most significant of them follow.

3.5.1 LandInfra and InfraGML

Of high relevance to our work is the LandInfra conceptual model and the corresponding InfraGML implementation standard (Open Geospatial Consortium, n.d.[d]). LandInfra is one of the most substantial efforts underway in the world aiming to bridge the divide between geometric and geospatial LRMs. Jointly developed by OGC and Building Smart International (bSI), these standards are at the forefront of providing interoperability between the Building Information Modelling (BIM) and GIS communities. We should ensure that our work is in alignment with these standards and leverage this knowledge wherever possible.

The scope of the Land and Infrastructure conceptual model is land and civil engineering infrastructure facilities. Subject areas include facilities, projects, alignment, road, railway, survey, land features, land division, and what is referred to as 'wet' infrastructure (storm drainage, wastewater and water distribution systems - 3 Waters in our parlance). Unfortunately for our purposes, to date this standard has targeted all of these areas except wet infrastructure. While there does not yet exist a LandInfra part focused on these underground utilities, the parts that focus on general facilities management as well as roads and rail are useful to our work. Development of a LandInfra part to support underground infrastructure is underway in conjunction with PipelineML and CityGML OGC domain working groups.

Figure 5 illustrates the structure of LandInfra and its parts. Parts 0 (core) through 5 (Railways) are of most significance to our work. Each child part inherits the characteristics of its parent - RoadCrossSection inherits properties from Roads which inherit properties from LandFeatures and Facility, both of which inherit from Core.

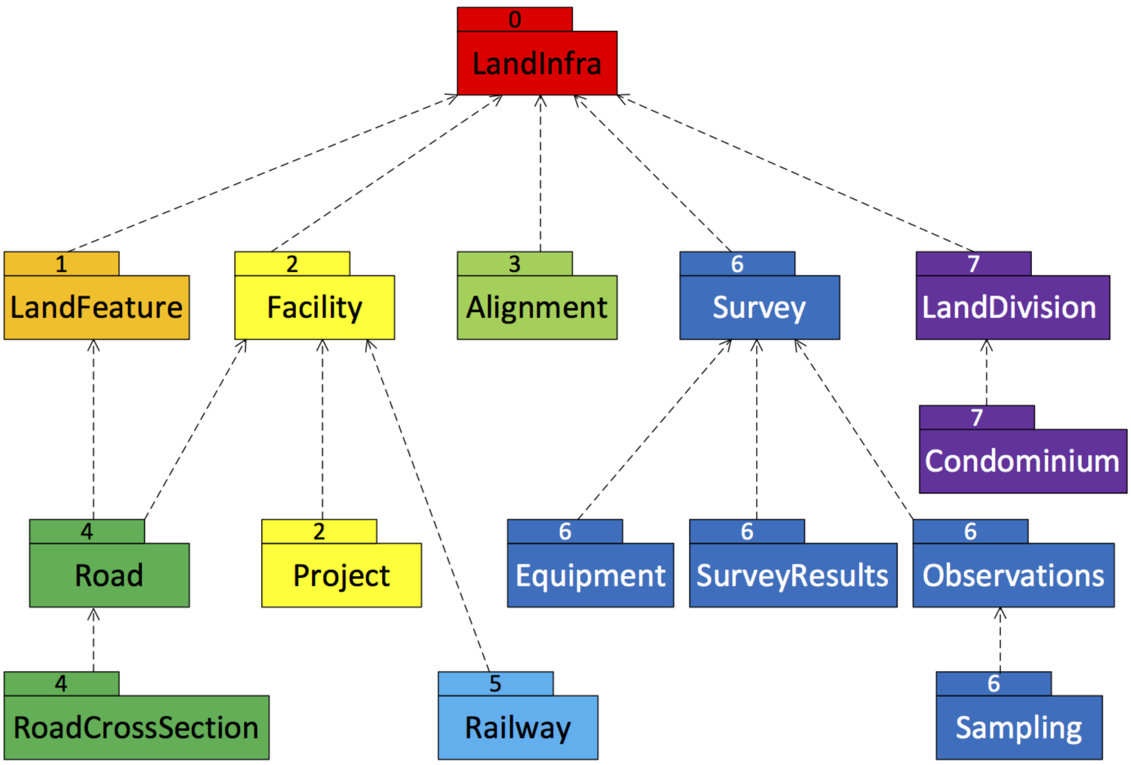


Figure 5: LandInfra Class Model - Parts 0 - 7

3.5.2 CityGML Utility Network ADE

An OGC standard, CityGML is an open data model and XML-based format primarily aimed to improve the storage and exchange of virtual 3D city models. It is an application schema for the Geography Markup Language (GML), an extendible international standard for spatial data exchange of urban buildings and infrastructure also overseen by the OGC and ISO TC211. The aim of the development of CityGML is to reach a common definition of the basic entities, attributes and relations of a 3D city model. This is especially important with respect to the cost-effective sustainable maintenance of such models, allowing the reuse of the same data in different application fields. In tandem with LandInfra, CityGML is used heavily to provide interoperability between BIM data and GIS data (Open Geospatial Consortium, n.d.).

While CityGML is intended to be a universal and application-independent geographic information model, the advent of dozens of applications and burgeoning use in different geographic contexts and software require additional information that is not readily available in the CityGML data model. This has led to the development of Application Domain Extensions (ADEs) to CityGML that augment its data model with additional concepts required by particular use cases. Of most interest in our context is the CityGML Utility Network ADE - draft standard (Bilijecki et al., 2018). This ADE has been used in numerous projects to support the mapping and modelling of underground utility networks in 3D city models. The UtilityNetworkADE defines a topological network model facilitating sophisticated analyses and simulations on utility networks and supplying infrastructures. Included are network hierarchies of arbitrary depth, nesting of network components, and modelling of multi-modal networks. It also allows for representing the network components as 3D topographic city objects. Being based on GML, it has the native capability to map locations using OGC and ISO TC211 geospatial LRM standards.

3.5.3 Land Administration Domain Model - ISO 19152 (LADM)

LADM defines a reference model covering basic information-related components of land administration, including those over water and land, and elements above and below the surface of the Earth (International Organization for Standardization, 2018). It provides an abstract, conceptual model with four classes:

1. Parties (people and organisations)
2. Basic administrative units, rights / responsibilities / restrictions (ownership rights)
3. Business units (parcels, and the legal space of buildings and utility networks)
4. Spatial sources (surveying) and spatial representations (geometry and topology). (Figure 6)

It provides a basic common terminology for ownership (and the rights, restrictions and responsibilities this entails), based on various national and international systems, that is as universal and as simple as possible in order to be useful in practice. The terminology allows a shared description of different formal or informal practices and procedures in various jurisdictions (International Standards Organization. 2018.)

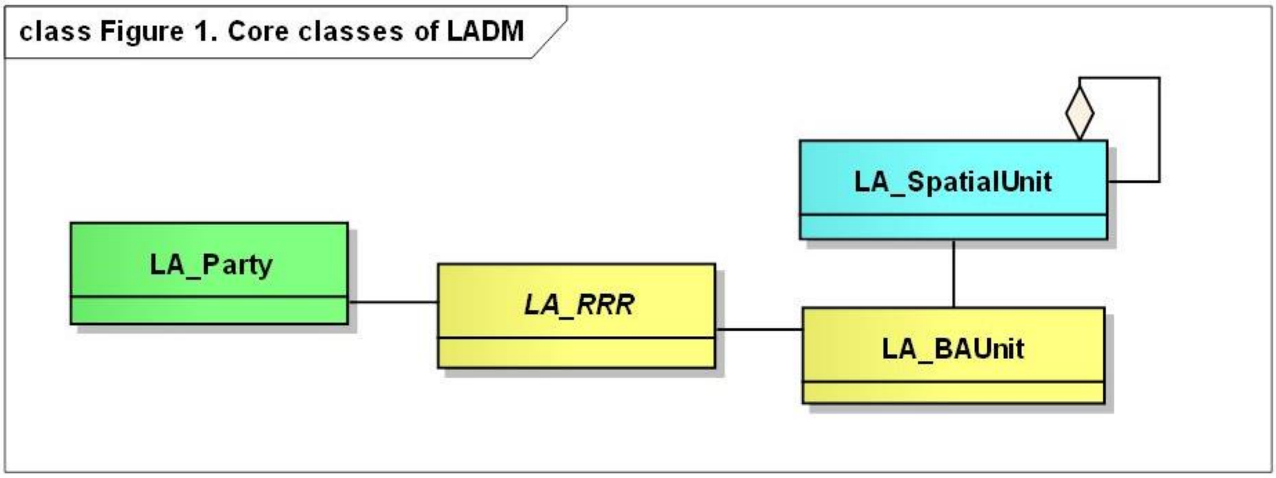


Figure 6: LADM Core Classes

In our context, the LADM is useful for addressing issues concerning who holds (LA_Party) the three R's - rights, responsibilities and restriction (LA_RRR) on a 'property' (LA_BAUnit) in a given location (LA_SpatialUnit). This standard can be used to address the expressed use cases where a provider requires information about who holds the responsibility, rights and restrictions on objects and property adjacent to one's own properties and projects.

3.5.4 GeoSynchronisation Service (GSS)

GSS, while not a full standard, is useful when multiple parties wish to share updates between data stores. GSS was developed to support the moderated synchronisation of data between repositories held by different organisations. It can be thought of as an OGC open standard version of the software that allows synchronisation of crowd-sourced data into the Open Street map project. This standard was suggested by OGC personnel to support Christchurch earthquake recovery efforts following the 2012 Canterbury Plugfest. Here, the issue being addressed was the smooth transference of as-built data for 3 Waters features from the Stronger Christchurch Infrastructure Rebuild Team (SCIRT) - originally drawn in 12D CAD - to the Christchurch City Council GIS Database. This idea was explored further in OGC Testbed 11 where LINZ sponsored activities to further develop the standard. GSS uses the OGC Web Features Service Transactions (WFS-T) standard along with a staging area for review to support the process (Open Geospatial Consortium, n.d.[h]). The original use case for this standard was the synchronisation of road information between local councils and province government transport bodies in Canada where review of the submitted data was required (Vretanos, 2011). A similar OGC standard, WFS Sync, has since been developed that can be implemented in trusted peer to peer situations where no review is required (Vretanos, 2017).

As GSS is a service standard, a fuller consideration of this can be deferred until a data standard for location is closer to implementation. It is worth considering at an early date our needs to standardise services by which we exchange spatial information.

3.5.5 Publish/Subscribe 1.0 (PubSub)

One issue that may need to be addressed is how we standardise our methods of notification to interested stakeholders that have new or changed location data. The OGC PubSub standard is designed to address this need (Open Geospatial Consortium, n.d.[e]). PubSub can be thought of as an auxiliary standard to better enable communication. This will be useful at a later stage when services that allow ease and automation of exchange are accepted.

The PubSub standard provides an interface specification that supports the core components and concepts of a message exchange pattern with OGC Web Services. With this service a provider can establish notification feeds to which interested parties can subscribe to be notified of any changes. The Publish/Subscribe pattern complements the Request/Reply pattern already in place in existing OGC Web Services. This specification may be used either in concert with, or independently of, existing OGC Web Services to publish data of interest to subscribers.

3.5.6 Discreet Global Grid Systems (DGGS)

We concur with the e-Spatial findings that Discreet Global Grid Systems are potentially very useful in our context (e-Spatial, 2019). However, this standard is still under development and not ready for implementation.

DGGS can be thought of as a new type of LRM that offers several advantages over traditional LRMs. Being Earth referenced, it lies in the geospatial LRM family and provides a highly efficient method of performing spatial analysis. Unlike traditional coordinate systems which provide zero dimensional points, DGGS is area based. Precision is inbuilt which aids in understanding to what a coordinate refers. (Traditional coordinate systems require metadata to understand precision.) As these areas are referenced by unique cell IDs, using the identifiers which provide both the index and identities of locations, DGGS can act as an address system to which objects can be linked.

An intriguing possibility is the application of DGGS to linear referencing problems. As a DGGS could reference any linear object such as a road or a pipe, since a set of area identifiers connect as a line, it should be possible to analyse these features in a way that is similar to dynamic segmentation. This warrants further research.

It should be noted that the Australian Location Index framework (Loc-I) which is moving rapidly towards development and implementation by Geoscience Australia and others, will be heavily reliant on DGGS technology. We recommend keeping pace with this work (Australian Location Index, n.d.).

The e-Spatial report provides a good explanation of DGGS with pros and cons (e-Spatial, 2019). The standard is currently under active development including OGC Testbed activities with OWL contributions to this work. The best way to keep informed is through the OGC DGGS domain working group website (Open Geospatial Consortium, n.d.(a)).

3.5.7 LINZ Utility Location Standard

The desire to look towards Land Information New Zealand as an authority to provide location standards was expressed at the 30 October workshop (Cochrane et al. 2019). We have since learned that LINZ is launching a project to support this in their planned Utility Location Standard (ULS). This could aid our work in many ways but, as promising as this is, it is unlikely to address all our issues.

LINZ's intent is to produce a brief for the development of the ULS standard hopefully by early 2020. It is anticipated that this would then be shared with interested stakeholders to inform them of the intent and scope of this work. This standard would specify coordinate systems (3D), accuracy, and a requirement to coordinate in terms of the geodetic control network (CORS). The ULS could be referenced in contracts used by any Utility Asset Manager that require the delivery of as-built documents for completed works. It would be designed for use by contractors, engineers and possibly surveyors. It is likely to specify NZTM and NZGD as coordinate systems and tie these coordinates to local CORS networks. It would be accurate to 10cm. The LINZ ULS would likely provide support for coordinate transformations that would adjust GNSS coordinates to datum changes (Anselm Haanen, NZ Surveyor General, personal communication, 12 December 2019).

3.5.8 Geometric standards not considered

There is no discussion in the e-Spatial report of geometric LRMs (CAD or BIM) as providing potential candidate standards (e-Spatial, 2019). But then, being project centric, it is unlikely that there exists a geometric location standard that would meet the described requirements. We have been unable to discover one. However, transitioning between geospatial and geometric LRMs continues to be a challenge that is of some import to the use stories shared in the e-Spatial report. As mentioned elsewhere, OGC LandInfra and to an extent, the less active ISO-19166 standard, are the places where this problem - the seamless navigation between BIM IFC codes and GIS CityGML, is likely to be best addressed.

3.6 Architectural concerns

Questions about how our solution fits in the broader system and the robustness of the design process will need further consideration. Provision of a location standard by itself does not assure identified problems will be solved.

3.6.1 User stories and personas

While the e-Spatial report contains a rich collection of user stories backed by well selected and described personas, it is our opinion that the analysis of these user stories is incomplete (e-Spatial, 2019). When read individually, many of the user stories do not support the recommended choice of ISO and OGC as a location standard for AMDS. For instance, requirements implied by User Story 1 are well addressed by the Austroads standard coupled with the promised LINZ Utility Location Standard. The cited related standards ISO-19107 (International Organization for Standardization, 2003) and ISO-19125 (International Organization for Standardization, 2004[a]) only come into play in an obscurely embedded fashion.

The greatest value of these user stories lies in providing a foundation to uncover the true requirements of our location standard(s) - particularly from the perspective of the personas as defined. From these user stories, more detailed use cases with multiple actors (often from different organisations) should be developed and collated where requirements overlap. Building detailed use cases of both the current and desired flow of information is a recommended next step in the process of developing a location standard.

The user stories gathered by e-Spatial could indicate that there may be less agreement as to scope than assumed. For instance, one question could be summarised as follows, ‘Is this to be a standardised way of recording location in inside other schemas or a location aspect of a larger asset management interchange standard?’ These two approaches need not be exclusive - it is possible to address location standards as guidance for use in existing systems and schemas while building a more comprehensive model later, but this is best known up front.

3.7 Other considerations

3.7.1 Metadata and discovery

Issues related to knowing what data is available and its fitness for use were major concerns voiced at the October 30 workshop and captured by our survey (Cochrane et al., 2019). Good documentation, notification, communication and discovery systems are important parts of interoperability. Good standardised metadata are key to providing this. Work underway by the ICSM Metadata Working Group should be referenced to provide guidance in this area (International Council on Surveying and Mapping, n.d.). ISO 19115-1 should provide the basis for metadata capture and storage while Catalogue Service for the Web should be considered to support the sharing of such records (International Organization for Standardization, 2014[a]).

3.7.2 Data quality

Concerns about data quality and how to address them warrant consideration. While this may be considered a documentation issue, it is also about community trust and understanding the requirements of other participants (and how they differ from yours). ISO 19157 provides guidance on data quality (International Organization for Standardization, 2013). This standard is currently under review. In New Zealand, this review is being led by NZ Transport Association personnel.

3.7.3 Forward works viewer

One project that is worth reviewing in the context of this effort is the Forwards Works Viewer. This planning and coordination tool was the largest project in the LINZ-led Canterbury SDI programme. It is still in operational service and is used to coordinate horizontal and vertical construction activities in Christchurch City as well as repairs relating to the rebuild of infrastructure following the Kaikōura earthquake of 2016. (Stronger Christchurch Infrastructure Rebuild Team. n.d.).

Forward Works is a system that better enables the sharing of data between surface, underground and vertical infrastructure at the project level in order to reduce conflict over the use of common space (such as roads). Organisations from all these infrastructure communities were involved in the design and use of this system. Agreements on data sharing made as part of the project could provide a useful guide for Location Standards work. The project opened up a great deal of utility data that was previously unavailable outside of the responsible agencies. Further development and deployment of the Forward Works tool could be encouraged by our work.

4 Workshop on 30 October 2019

On 30 October 2019, OWL conducted a workshop on behalf of NZTA and Quake Centre about location standards titled ‘Workshop #2 on Asset Management Data Standards (AMDS) - Location Standards’. This followed an earlier Workshop 1 held in May 2019 on the same topic. While the first workshop focused primarily on the needs of the roading sector, the participants for this second workshop came from a larger cross-section of organisations and domains including many from the 3 Waters, railroad and electrical power domains. Participants represented local and national government, engineering firms and contractors, utility and transport agencies.

The major findings of the e-Spatial report (e-Spatial, 2019) were presented and discussed at length. From this we concluded the 30 October workshop with agreement and consensus on a number of items.

4.1 30 October workshop agreements

1. The desired outcome of this work is the seamless sharing of location data so that:

   a. Data are not recreated unnecessarily.

   b. Authoritative data are known and available.

   c. Results will be transformative and valuable for the nation.

2. This requires the establishment of nationally agreed location standard(s) for the exchange of horizontal infrastructure (transport and utility) asset data to support cross domain interoperability. Such standard(s) will meet the following requirements:

   a. They will be international standards, consensus and best practice wherever possible.

   b. They will be open as per the DIA definition of 'open standard’.

   c. Where necessary, they will be properly profiled to suit NZ needs.

   d. Proper governance will be provided by the community of users.

   e. They will be aligned with the Utility Location Standard (under development) and other relevant LINZ activities.

3. Geospatial will be the primary means of transmitting (exchanging) location between organisations where:
    a. Different location referencing models may be used internally.
    b. The interchange standard by which external data are related will be Geospatial.
    c. Geospatial locations will be recorded for assets to a consistent known accuracy and precision (captured in metadata).
    d. Geospatial locations will be recorded for assets to a consistent known Coordinate Reference Systems (CRS) with guidance from LINZ.
4. Linear reference will be supported as a secondary means of capturing asset location:
    a. In a way that is analogous to street address
    b. To support current asset management systems
    c. To aid dynamic segmentation.
5. Accessible standardised metadata will be collected and shared that:
    a. Documents the coordinate reference system used
    b. Captures Data Quality - fitness to purpose and the precision and accuracy of measurements
    c. Records Provenance (Lineage) including consistency, method of capture, system of encoding
    d. Follows national guidance from authoritative national agencies / standards body / endorsed reference standards (corpus of standards).
6. NZTA will fund governance for the duration of project (currently projected to be 9 years):
    a. Appropriate governance will be established at the appropriate level with an appropriate mandate.
    b. These standards will be cared for as a national infrastructure in and of themselves.

5 Survey results

A Survey created by OWL was released on 26 November 2019 and completed on 4 December 2019.

It was sent to 27 people from 22 different organisations.

We received 13 responses from 12 organisations

The respondents were categorised as follows:

- Local government
- National government
- Engineering firm / contractor
- Utility or transport company

5.1 Purpose

This survey was designed as a follow-up to the NZTA Asset Management workshops. While good consensus was reached on the use of geospatial location standards from ISO and OGC as the primary method by which location information will be exchanged, this survey focused on potential barriers that may be faced in implementing and using such standards within organisations for daily business.

This survey will help guide us in designing the best approaches to overcome such challenges. Identifying the largest and most common challenges will help us develop an effective implementation plan. Understanding the different challenges that different organisations and sectors face will help ensure that plans are fit to purpose.

The survey starts with a section on values that participants feel will be enhanced by the use of such standards. Alignment with organisational values will help us devise good strategies to achieve adoption and support within organisations. These responses help summarise the reasons and perceived benefits for adoption of these common standards.

The questions are divided into several categories. At the end of each group respondents were presented the opportunity add comments to their input.

The full Survey with responses is included in Appendix B

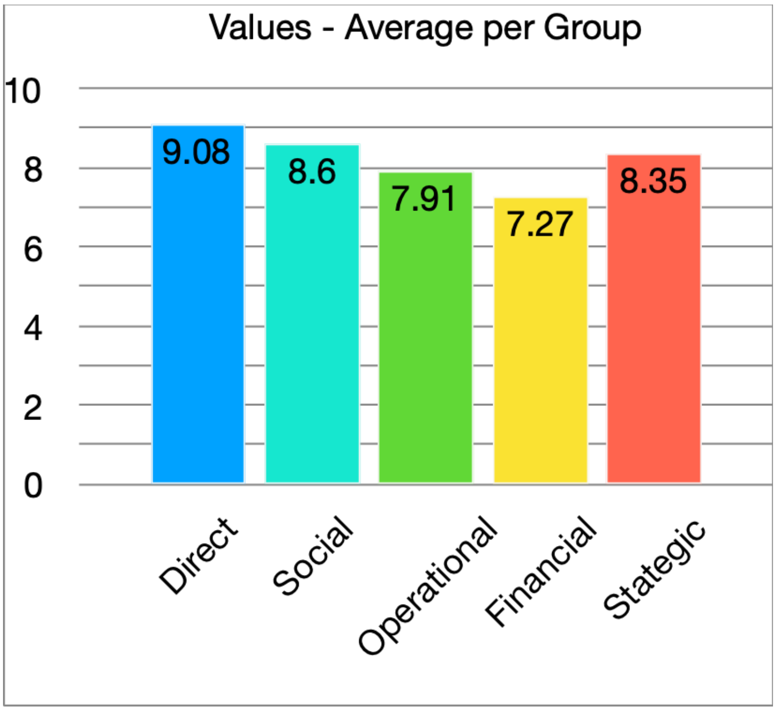


Figure 7: Survey averages by Value question group

5.2 Notable findings

Values - Highest agreements overall (average score out of 10)

Individual questions:

- High
  - Cross-agency coordination - 9.23
  - Improved data availability - 9.08 with strong agreement
  - Ease of integration with other systems - 9.08 with less agreement
- Low
  - IT performance improvement - 6.23
  - Improved international collaboration - 6.69

By category:

- Highest
  - Social values - 8.6
  - Strategic / political values - 8.35
- Lowest
  - Financial - 7.17

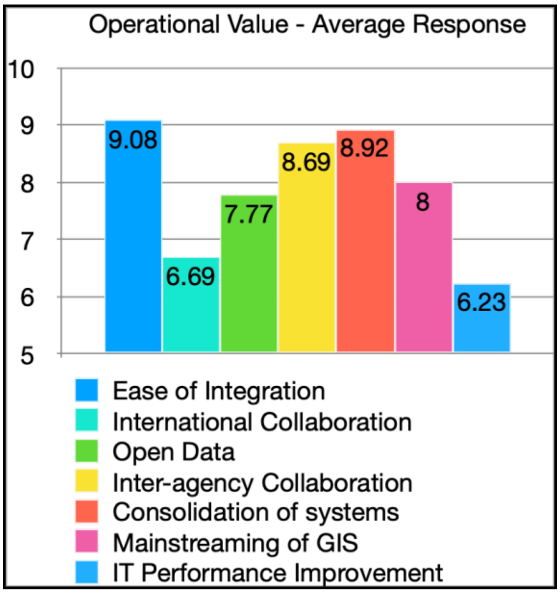


Figure 9: Average values of responses - Operational factors

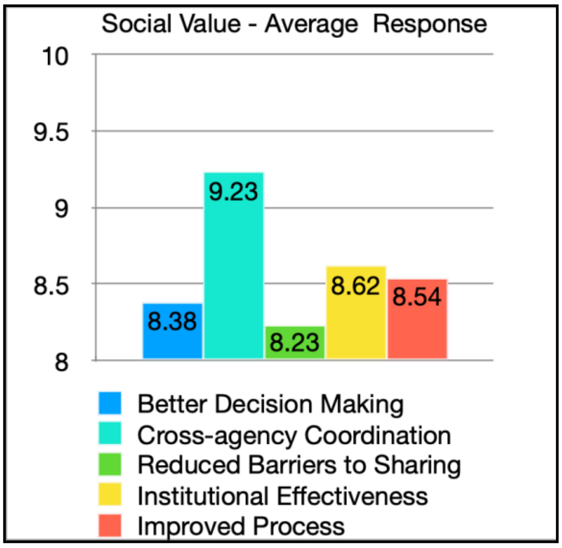


Figure 8: Average values of responses - Social factors

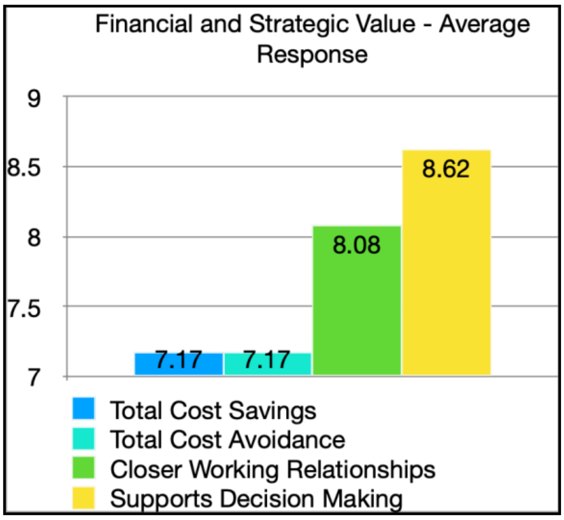


Figure 10: Average values of responses - Financial and Strategic factors

Challenges - greatest agreement

Individual questions:

- Are there concerns that lack of documentation and metadata may hinder use of shared data? –

  91.67% answered Yes

- Is potential poor governance of your data sharing community a concern; be it in structure or execution - e.g. failure to meet, communicate, form agreements…?

  87.5% answered Yes

- Are there concerns about the quality of digital data received and shared? –

  81.82% answered Yes

- Are there concerns about availability of skilled personnel to support potential changes?

  75% answered Yes

Categories:

- The category where respondents most consistently expressed concerns was Data Issues.
- Community and Governance issues had good agreement as being of concern from those who responded to this section, but many left this section blank which could skew the results.

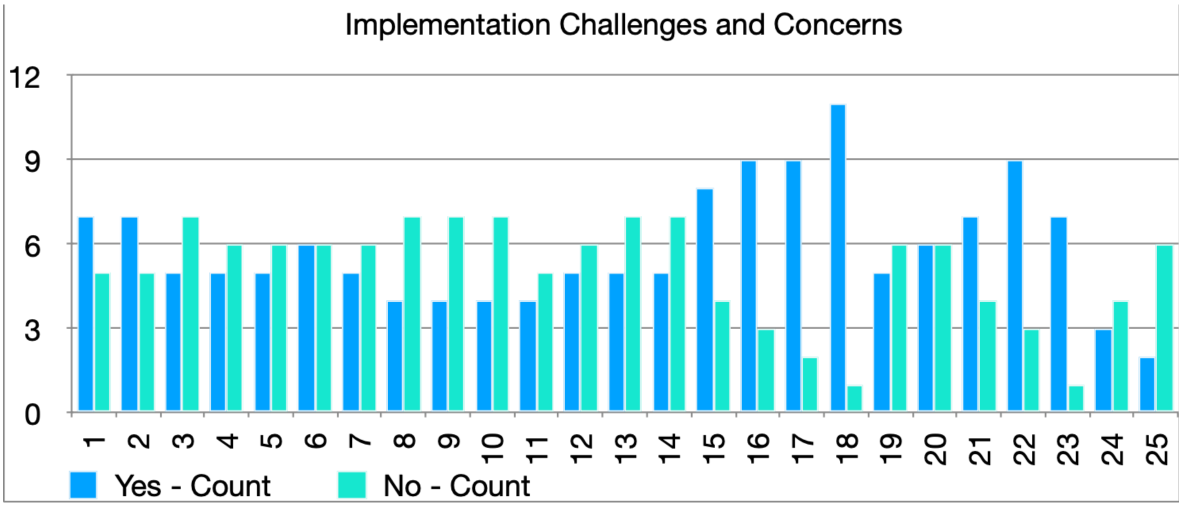


Figure 11: Implementation Challenges and Concerns summarised responses

No.	Question
1	Do there exist rules and institutional arrangements that seem likely to hinder adoption of these standards?
2	Does a lack of formal obligations to require standards challenge implementation; be these legal, regulatory, contractual or other requirement?
3	Is there sufficient awareness by your organisation's management of the value of these standards?
4	Does there exist an adequate business case to support return on investment? Is the existing investment by the organisation in quality geospatial location data understood?
5	Is your management comfortable in making funding available for building and curating data?
6	Does management understand the skills, competencies, and knowledge needed by the organisation in the geospatial domain now (and in the future)?
7	Does there exist a lack of support for these standards by your software and data vendors?
8	Does your organisation currently use proprietary solutions that obfuscate the need to implement these standards?
9	Do your customers perceive issues with privacy, such as poor anonymisation of data?

No.	Question
10	Are there corporate trade secrets or other organisational IP that is feared will not be protected?
11	Do there exist public safety and security concerns with sharing data?
12	Are there concerns around authentication regimes used in the sharing of data?
13	Are there concerns that the old system supports your particular needs where new ones will not?
14	Are there fears that a new system will change business processes and hinder business as usual?
15	Does perceived difficulty to translate data to a new model create barriers?
16	Are there concerns about availability of skilled personnel to support potential changes?
17	Are there concerns about the quality of digital data received and shared?
18	Are there concerns that lack of documentation and metadata may hinder use of shared data?
19	Would the adoption of these standards face resistance expressed as "reluctance to change" by members of your organisation?
20	Do you believe that your Stakeholders may express resistance?
21	Do you fear that your organisation may fail to understand relevancy? That there are more important things to address or that the chosen solution may make things worse?
22	Is location data valued as a business asset by your organisation?
23	Is potential poor governance of your data sharing community a concern; be it in structure or execution - e.g. failure to meet, communicate, form agreements...?
24	Does your data sharing community have sufficient focus and commitment necessary to succeed?
25	Do sufficient cooperative agreements exist that guarantee a seat at the table for participants?

5.3 Variances of results by organisational type

There were some notable differences when viewing the results by organisational type. While the number of respondents was too low to make determinative conclusions (particularly in some categories) this does suggest that it may be beneficial to develop different approaches to implementation for different categories of participant.

5.3.1 Values

Financial benefits were somewhat surprisingly viewed as very high by all government participants but less so by in the utility, transportation and private sectors.

Improved international collaboration was perhaps unsurprisingly viewed with higher value by government bodies than non-governmental.

Both national government responders to this survey ranked Mainstreaming of GIS throughout Organisation and to a lesser extent, IT Performance Improvement lower than all other groups.

5.3.2 Challenges

More significant difference exists by organisation type when respondents were asked about perceived challenges. The patterns are clear, but due to the limited number of respondents and the increase in non-response rate in this section, further research is warranted before developing an implementation plan. The results we do have suggest that implementation plans should be customised to organisation types.

National government

The two national government respondents left many questions unanswered in this section and did not align on any of the answered questions. Therefore, little weight is given to their binary responses. Comments and aggregate scores should still be considered.

Engineering firms and contractors

The Bureaucratic and Management Issues, and Vendor Issues responses express near consistent consensus between all engineering firms and contractors that challenges exist in all areas except Privacy and Security. There are some notable exceptions. The following questions elicited positive responses from these participants:

- Does management understand the skills, competencies, and knowledge needed by the organisation in the geospatial domain now (and in the future)?
- Is location data valued as a business asset by your organisation?

This is at odds with the results from other sectors who generally gave more negative responses to these questions. These engineering firms and contractors commonly work heavily with geometric LRMs (CAD and BIM). Consistent with international experience, those working in the BIM space have found major software vendors hesitant to support the new standards that they have helped develop e.g. LandInfra and InfraGML (Personal communication, OCD LandINfra DWG meeting, Banff, Canada, Sept 2019).

Utility and transport companies

There is little commonality in the challenge's responses from the utility and transport companies except in a few questions, including:

- Do you fear that your organisation may fail to understand relevancy? That there are more important things to address or that the chosen solution may make things worse?
- Are there concerns about availability of skilled personnel to support potential changes?
- Does management understand the skills, competencies, and knowledge needed by the organisation in the geospatial domain now (and in the future)?

This sector expressed more concern than most others for these questions, suggesting that an education campaign aimed at the management level could be of value.

Local government

Like Utilities, this sector also expressed concern at the question:

- Does management understand the skills, competencies, and knowledge needed by the organisation in the geospatial domain now (and in the future)?

But, perhaps due to the increasing use of open source solutions in this sector, local government showed no concern about the question:

- Does your organisation currently use proprietary solutions that obfuscate the need to implement these standards?

This group also showed little concern in response to:

- Do you believe that your Stakeholders may express resistance?
- Is location data valued as a business asset by your organisation?

This could indicate an openness to adjusting business practices to implement our chosen location standard in this important sector.

5.4 Likely pitfalls to implementation

5.4.1 Summary from survey

Overall, four areas stood out as concerns shared by the group. These can be summarised in order of agreement as:

1. Poor documentation of resources (lack of metadata)
2. The community not being sustained or well governed
3. Concerns about potential poor data quality (This may relate to point 1 above. Without good documentation how can the quality be known?)
4. Concerns about availability of skilled personnel (This could point to a need for education to be included in our designed solutions.).

5.4.2 Suggested workable approaches

1. Design an information campaign that focuses on the shared values of:
    a. Cross-agency coordination
    b. Improved data availability
    c. Ease of integration with other systems.
2. While addressing the issues of:
    a. Metadata - training in the capture of metadata and implementation of catalogues
    b. Governance and community building - as specific tasks properly agreed and documented
    c. Understanding the standards and how to implement them - training sessions for leaders.
3. Customise educational materials to suit groups:
    a. Adapted to different sector requirements
    b. Address both administrative and technical skills.
4. Establish the governance groups early to address these and other issues:
    a. Secure official commitment of NZTA to sustain this for duration of project (as previously agreed)

b. Establish membership, bylaws, officers and meeting schedules

c. Two levels of governance with close cooperation:

    i. Technical leaders who can identify and propose solutions to issues

    ii. Management that can make business and funding decisions

d. Enable communication channels for groups.

6 Proposed interoperability experiment

In the 30 October workshop it was agreed that a sensible way to progress would be via an OGC Interoperability Experiment. The benefits of such an approach would be that it would ensure:

- alignment with international best practice and standards
- international knowledge, experience and expertise is well leveraged
- sustainability of our chosen solution
- better compatibility with existing software in common use.

OGC Interoperability Experiments have been described in detail above. In this section we wish to enumerate some related activities on which such an OGC IE would build. The primary point where this proposed IE differs from previous ones (and which may make it attractive to OGC members) is testing a solution that is cross domain - utility and transport sectors utilising a common location standard. In many respects the IE could be a pre-cursor for the Quake Centre's aim of creating a National Digital Infrastructure Model (NDIM) (Personal communication, Greg Preston, Manager, Quake Centre). The timeline for an OGC IE would be six months to a year after initiation and would require that at least the lead agency be an OGC member at the associate level.

It should be noted that an OGC IE will require a greater degree of flexibility and compromise than an exclusively New Zealand-based activity due to the inclusion of more parties from which to gain consensus. This would apply to both timing and content of the IE. Past experience has been that OGC oversight makes this a far less onerous task than it would otherwise be.

6.1 Relevant previous OGC IPactivities - International

6.1.1 MUDDI Pilot

The Model for Underground Data Definition and Integration (MUDDI) OGC Pilot project was focused on underground infrastructure in NYC.

- Its aim was to lead to verified, standards-based interoperability for 'smarter' underground projects in cities around the world.
- The pilot was preceded by the OGC Underground Infrastructure Concept Development Study, which investigated ways of improving public safety, project delivery and urban resilience based on a secure 3D repository of urban underground infrastructure.

- The OGC Underground Infrastructure Pilot: MUDDI ETL-Plugfest Workshop was held at the Fund for the City of New York (FCNY) on 24 – 25 July 2018. One of its primary goals was to evaluate the Underground Data Conceptual Model ("MUDDI Data Model") through implementation and testing so as to provide feedback on how to refine and improve it, as well as to guide the choice and development of standard implementations.
- Another workshop goal was to review a draft version of an underground data RoI model Cost Benefit Assessment of Subterranean Information Management (under review). This model is intended to help justify investments in underground data gathering and sharing by documenting multiple sources of returns on such investment and providing a methodology for estimating their value. It is offered as a shared community asset, a work in progress that would stand to benefit from participant feedback (Open Geospatial Consortium, n.d.[i].

6 use cases

- Routine street excavations (EX)
- Planning, design and construction of large-scale projects (AE)
- Disaster planning and response (DP)
- Utility related emergency response (ER)
- Private and public utility operations, maintenance, repair and replacement programs (OM)
- Smart cities, future cities (SC).

Candidate underground information models reviewed

- CityGML Utility Network ADE (Application Domain Extension)
- INSPIRE Utility Networks
- IMKL (Information model for cable and pipes) Includes Flanders KLIP and KLIM standards
- ESRI Utility Network Model.

6.2 Relevant previous OGC IP activities - New Zealand

6.2.1 TestBed 11 and Canterbury Plugfest

New Zealand (LINZ) participation in these efforts in large part revolved around issues closely related to the efforts to create a Location Standard to enable better interoperability between geometric and geospatial systems.

Canterbury Plugfest

The problem being addressed was the submission of waste-water assets ‘as-builts’ from SCIRT to Christchurch City Council (CCC), and SCIRT consuming water infrastructure data for project design purposes (Van der Vlugt & Murcott, 2012).

This Plugfest took place in the LINZ offices in Christchurch between the 22 and 24 May 2012. The degree of active collaboration between parties was exceptional. The pursuit of a common purpose brought together technical staff who would not normally meet, let alone work, together. During the period they were able to create and demonstrate interoperability using the powerful transaction-based extension of the Web Feature Service (WFS-T) for both scenarios.

OGC Testbed 11

Building on the work of the Canterbury Plugfest and to further meet the goals of the Canterbury SDI programme, LINZ became a sponsor of the OGC Testbed 11. The aims being to further development of solutions uncovered and yet unresolved by the Canterbury Plugfest. The focus was the exchange of locational information related to 3 Waters data in an emergency situation (flooding). It was felt that participation led to significantly shorter development time for standards such as OGC API Features. This new standard modernises the existing WFS standard to ease integration into mainstream web development methods (Open Geospatial Consortium, n.d.[h]).

6.2.2 Soil Data IE

The first New Zealand involvement in an OGC IE occurred when Landcare Research, together with the Commonwealth Scientific and Industrial Research Organisation, Australia (CSIRO), and the International Soil Reference and Information Centre, Netherlands (ISRIC) together led the Soil Data IE in 2015. This is considered a model Interoperability Experiment by the OGC and the methods and approaches have been shared with other OGC members regionally and internationally to improve the process. The primary technical aim of the Soil Data IE was to combine soils data sourced from around the world and stored in different schemas seamlessly and view these data as one common dataset. Methods of deriving data on the fly were demonstrated where data schemas did not align (Open Geospatial Consortium, n.d.[g]).

6.2.3 ELFIE and SELFIE

In part as a follow-on to the successes of the Soil Data IE, Landcare Research together with LINZ joined a consortium of international OGC members led by the United States Geologic Survey (UGS) to conduct the Environmental Linked Features Interoperability Experiment (ELFIE). ELFIE and its follow-on IE Second ELFIE (SELFIE) were designed to interoperate between environmental domain feature models that have been established by a number of sub-domain groups. These IEs were designed to uncover best practice or standard methodology to encode documents containing links between and among domain features, such as a rivers, aquifers or soils, and observational data about those features. (S)ELFIE sought common approaches to encoding such links as required to allow cross-domain and cross-system sharing and interoperability linked information.

While the domains addressed in the Soil Data IE and (S)ELFIE differ from that under consideration here, the interoperability infrastructure tested is informative to our situation. Furthermore, the local experience gained conducting OGC IE is valuable. Byron Cochrane served as the technical lead for ELFIE on behalf of LINZ and Alistair Ritchie of Landcare Research served the same role for the Soil Data IE and the ongoing SELFIE, thus providing local reference cases and expertise in OGC IE (Open Geospatial Consortium, n.d.(b) and n.d.(f)).

7 Recommendations

Infobox

Within Australia and New Zealand, experience suggests that business drivers overwhelm well-intentioned moves to reform location referencing to a common method.

Scoping Study for a Location Referencing Model to Support the BIM Environment - Austroads

7.1 E-spatial report proposed next steps

The e-Spatial roadmap proposes an AMDS Location Sprint 2 to be completed in the first quarter of 2020. This is to be comprised of three parts - Continuous Review, Data Modelling and Consultation (e-Spatial, 2019).

The first stage of this work is focused on NZTA ADMS requirements. While other standards-setting stakeholders are included, they are not participants but are consulted to maintain relationships. The active participants are to be limited to NZTA AMDS, e-Spatial and ISO/OGC committee members.

The second stage is to model the standard in UML in alignment with the AMDS entity model. It includes a proposal to support dynamic segmentation as a secondary location reference system.

The third stage involves consultation with a Location Reference Group of industry experts before handover of this standard to the NZTA AMDS team.

7.1.1 OWL response

Working in support and from the point of view of utilities, we have some concerns and suggestions for improvement of this proposed Sprint.

The number of participants to be included in stage one of the process is, in our opinion, too small. While limiting the numbers as proposed may simplify the logistics of developing a location standard, it introduces a potential cost by creating a solution that suits only a small number of users - namely the NZTA ADMS team. To gain the advantages sought by the workshop participants, it is most important that perspectives from key experts across the utility community and other interested domains such as rail be included throughout the standards process. This will ensure that the selected standards solution is useful to all these communities. The problem is already hard. Inclusion of a few more voices is unlikely to make it significantly more difficult. A good standards process requires community consensus and compromise. It should not be rushed.

We agree with the stage two proposal to include dynamic referencing as a secondary aspect to the standard. The inclusion of ways to interface with linear referencing systems is needed in order to support asset data management as currently practised and standardised in ISO-55000 (International Organization for Standardization, 2014). We would suggest that interfaces with geometric LRMs also be considered at this stage to ensure the solution interoperates more fully with the design and engineering sectors involved.

We would suggest that the stage three Location Reference Group be an ongoing governance body that is for the present funded and chaired by NZTA ADMS team. Management of resulting standards should be the responsibility of a governance group that would include representatives from the major organisations in this data sharing community. We further suggest that stage three be moved forward so that this governance can be applied as soon as possible.

It is stated by e-Spatial that, the user stories outlined key themes for a fit for purpose location standard. (e-Spatial Report, 2019). But, in our analysis, there is not a clear path of reasoning shown between these stories and the stated conclusions. These stories have not been as fully leveraged and analysed to capture and prioritise the requirements of the community of potential users. The stories present a wide range of perspectives that unfortunately do not point to one obvious location standard solution. There is more to be learned from them. Many of the stories spoke of the use of linear and geometric LRMs as necessary for BAU without mention of geospatial solutions. While it is clear from the workshops that there is consensus on creating a geospatial location standard as the primary way that location data is exchanged, it is clear from these user stories and from our own survey, that there is a high risk many may will feel left behind if other location LRMs currently in use are not taken well into account.

It is our belief that an additional workshop is necessary to tease out the full list of requirements and priorities. A good start would be to turn these user stories into use cases to aid identification of common patterns in workflows that may point towards common solutions. This would include cataloguing a fuller list of systems and standards that the data flows must support and identifying a more complete list of standards and best practices that may provide solutions. This proposed workshop is detailed below.

7.2 Shared vocabularies

Data standards as discussed earlier provide a way to communicate and share information. Perhaps the most common pitfall which causes miscommunication is ambiguity - a lack of agreement about terminology and definitions. It is our recommendation that any standards process begin by establishing methods to capture and share common understandings of vocabularies. This can help eliminate potential misunderstandings as the project progresses. The process of building a shared common language also aids in community building and should be initiated at the earliest convenience.

Building controlled vocabularies need not be an onerous or even focused activity. Preferably, it would be an integrated structured process that resolves and captures agreements on vocabularies as they occur. As better consensus on meaning evolves, controlled vocabularies need be updated and shared. An online registry is the tool designed and suited to this purpose. A review of existing registries that may suit our community's needs is recommended. Establishment of a new registry controlled by our community may be needed to augment existing services.

Whenever possible, we strongly advise the use of existing controlled vocabularies and only augmenting these when absolutely necessary. Independent registries containing controlled vocabularies can incur significant technological debt. It is possible to create a registry that uses vocabularies from multiple sources. This incurs much less maintenance overhead than custom definitions.

7.3 Governance

It is important that we keep in mind that this is a standards collaboration process and not a software development process. While there are similarities, there are some important distinctions. Like open source, open standards are consensus based and transparent. They both invite the contribution of all interested stakeholders through an extensive network of members.

But open standards collaboration involves an even larger task of collaboration, consensus and community building. While tactics such as 'fail fast', 'short sprints' and 'minimal viable product' work well in open source projects, they tend to run counter to open standards work. Building and maintaining a community that wishes to share information is key to a successful standard.

Governance of open standards is similar to governance of open source software, but standards require greater consensus. Multiple competing applications are fine. Multiple competing standards not so much.

It is our recommendation that governance be treated as an early, top level concern and be given ongoing support. As NZTA has committed to supporting governance, they should lead the formation of a governance community for location standards and formalise this at the earliest convenience. Two levels of governance should be established - technical and managerial - with clear channels of communication between the two. The technical group should be led by technical leads from participating organisations. Managers should have sufficient authority to make business decisions and approve funding. The first task can be as a review and guidance group to standards work currently underway and suggested in this document and the e-Spatial report (e-Spatial, 2019). How these tasks are split between the two groups will be determined by the governance rules adopted.

At earliest convenience establish the governance groups to address these and other issues:

1. Secure official commitment of NZTA to sustain this for duration of project (as previously agreed).
2. Establish membership, bylaws, officers and meeting schedules:
    a. Decide and document how one becomes a member.
    b. Detail the rights, restrictions and responsibilities of members.
3. Two levels of governance with close cooperation:
    a. Technical leaders who can identify and propose solutions to issues
    b. Management that can make business and funding decisions.
4. Establish and enable communication channels for groups.

Establishment of such a governance framework will help create the structure and stability needed for interoperability to flourish.

7.4 Informational / educational campaign

Communication and education are important to progressing this work. Creating ongoing documentation of our work will not only inform interested parties that we may need to support and sign off on our work but will also provide a reference by which we can inform and remind ourselves of our accomplishments, aims and purpose. An informational campaign will aid us and others by demystifying what we are doing and sharing the expectation of benefits to be had. Such documentation would also describe what needs to be done to prepare and allow us and others to know how to contribute.

Educational materials should also be compiled from an early date. These should be aimed at two audiences:

- For managers to understand how to implement in their respective organisations
- For technical skill building of frontline personnel.

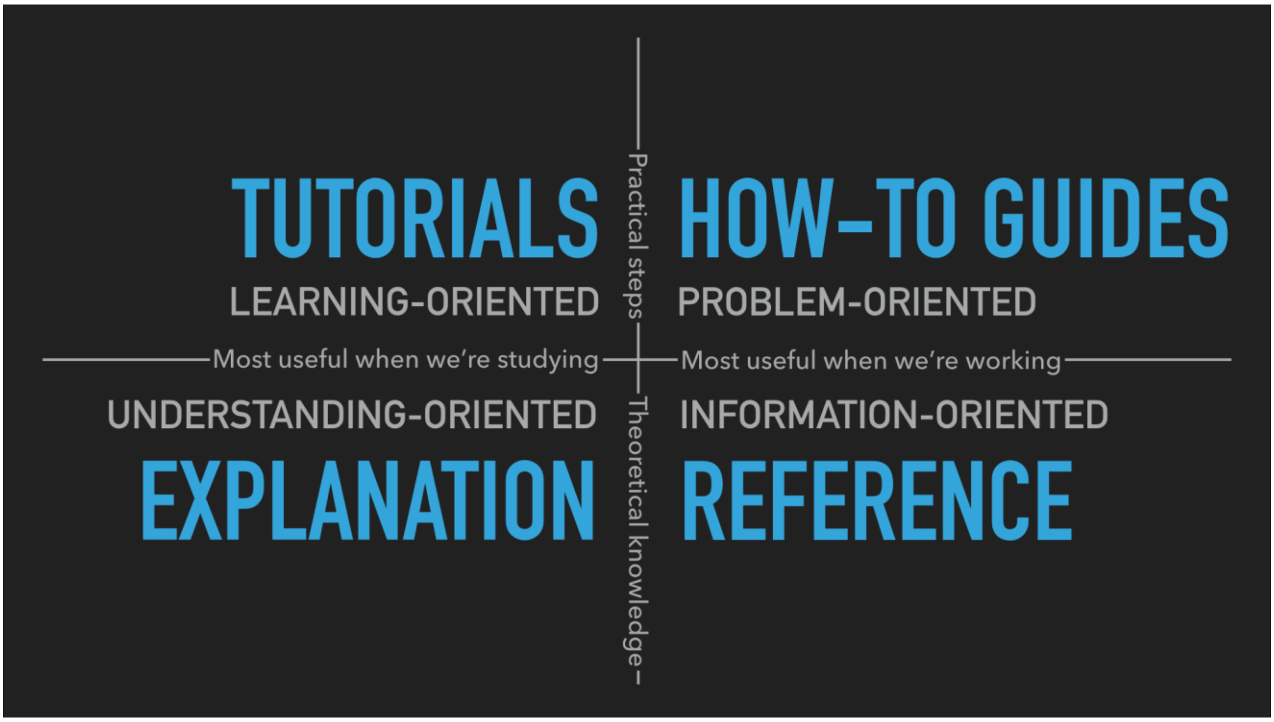


Figure 12: Used with permission from Divio

We recommended that these documents follow the guidance described by David Procida at Divio. He describes four documentation types:

1. Tutorials
2. How-to guides
3. Explanation
4. Technical reference.

They represent four different purposes or functions and require four different approaches to their creation. Understanding the implications of this will help improve most documentation - often immensely.

7.5 Use case review workshop

At earliest convenience a workshop focusing on the user stories and survey results should be held. The aim would be to distil the detailed requirements from these sources. This would include consideration of additional standards, best practices and other tools that fit the requirements.

There may be some hard decisions to make. Not all the user stories imply solutions that our choice of a geospatial location standard will best address. Some, when viewed in isolation, suggest opposite approaches based on linear referencing or geometric LRMs. When viewed in combination with similar user stories, use cases and survey results, we may uncover commonalities that hopefully suggest common solutions while keeping true to the stated aim of location standards based on ISO-TC211 and OGC standards.

These requirements will need to be prioritised. This may require some tough choices. Doing this as a group we hope would build community and test some governance rules.

The agenda for such a workshop may include:

1. Revise user stories and survey results to identify alignment with additional standards and best practices.
2. Restate user stories as use case to find commonalities in workflow and users.
3. Distil requirements and scope of our work.
4. Differentiate between standards we use and standards with which we need to interface.
5. Priortise requirements and adjust scope.
6. Agree on next steps.

Preliminary review of the stories and survey results suggest that issues such as metadata and data quality will need to be addressed. An overview and discussion of related standards and activities could be included covering the following as previously discussed:

- LINZ Utility Location Standard (Invite LINZ personnel to present)
- Geometric LRMs and conversion to Geospatial needs
- Metadata and documentation
- Data quality standards
- Service and communication standards requirements
- LandInfra and InfraGML
- CityGML Utility Network ADE
- Forward Works Viewer.

Others of less immediate significance include:

- Land Administration Domain Model – ISO-19152 (LADM)
- GeoSynchronisation Service (GSS) and related web service standards
- Publish/Subscribe 1.0 (PubSub) and other notification standards
- Discreet Global Grid Systems (DGGS).

In addition, vocabulary capture processes should be included as an embedded part of this workshop.

Appendix B contains a summary of survey results

Appendix C contains user stories plus additional notes.

7.6 Architectural design review

The Use Case Review Workshop will provide input for an architecture review of proposed solutions. The priorities determined and requirements derived will provide guidance on our architectural model. It is our opinion that this work would be best initiated in the aforementioned workshop and augmented through the use of online collaboration tools such as Loomio (see https://www.loomio.org/) and incorporated into the e-Spatial roadmap (e-Spatial, 2019).

Future model development needs to address the hierarchy of standards referenced and used, from Metamodels to Implementation standards (see Appendix D). Well described support for data interchange between LRMs is critical to success of an architecture model. At the application level this may be addressed for now by tools like FME, but the aim should be to reduce the need for such middleware. The model should also consider how the resulting standards will be compatible with other major systems with which they will be required to interact.

Questions about how our solution fits in the broader system currently in place amongst stakeholders and the robustness of the design process need to be considered. Provision of a location standard does not in itself ensure the problems will be solved.

7.7 OGC Interoperability experiment

In the 30 October workshop, it was agreed that a sensible way to progress would be via an OGC Interoperability Experiment (Cochrane et al., 2019). Preliminary enquiries with the OGC indicate that an IE with a point of difference being a common location standard for the utility and transport sectors would be well received.

We recommend this approach as an effective method to establish the desired national location standards. OGC IEs are designed to build on previous standards work, particularly previous interoperability programme efforts. Through the leverage of international expertise such an approach is cost effective, robust, compatible with international consensus and thus sustainable.

This approach would require OGC membership by at least one of the primary organisations in our group. The next step would be to organise participants and their contributions, first within New Zealand and then, with OGC assistance, internationally. From this point, the IE can be designed and executed, in consultation with all participants and the assistance of the OGC. From initiation to completion normally takes about one year. The output would be a well-tested solutions and engineering report (ER) which will contribute to further standards development that is suited to local NZ requirements.

It should be noted that an OGC IE will demand a greater degree of flexibility and compromise than an exclusively New Zealand based activity since consensus will need to be achieved between more parties. This would apply both to timing and content of the IE. Past experience indicates that OGC oversight makes these a far less onerous than would otherwise be the case.

More information about the OGC Interoperability Program and Interoperability Experiments can be found on the OGC website (Open Geospatial Consortium, n.d.(c)).

8 Conclusion

We have no major concerns with the findings and recommendations in the e-Spatial report (e-Spatial, 2019). ISO and OGC standards are the correct approach for this work due to their openness, interoperability and internationally tested background.

We would, however, like to offer some suggestions as detailed above in our recommendations section be incorporated into the proposed roadmap to increase the chance of this work achieving the desired outcomes. The number one recommendation is to treat this more as a standards process and less as software development. This means a heavier emphasis on inclusion, consensus and compromise, and less on speed and early deliverables. While this may slow the process in the short term, it will provide useful solutions that can be sustained, maintained and improved into the future.

We recommend that e-Spatial continue to progress the roadmap as planned with adjustments to keep in alignment with the following actions:

1. Design and implement the Governance structure of your community of stakeholders.
2. Establish shared vocabularies as a first step towards interoperability.
    a. Create a shared vocabulary as an ongoing practice starting with terms from these reports. Wherever possible, use existing vocabularies.
    b. Create or find a registry in which to hold vocabularies in a universally accessible way.
3. Keep abreast and get involved with the LINZ effort to create a Utility Location Standard.
4. Conduct a workshop to refine the requirements in the user stories and survey findings.
5. Apply the workshop findings to a system architectural design review.
6. Engage with the OGC to design an Interoperability Experiment that test solutions.
7. Launch a socialisation and education campaign including:
    a. Management level guidance customised to organisation type
    b. Technical training materials and documents as needed

8. Consider membership in standards organisations to ensure alignment and leverage expertise.

    a. At least one lead agency of our group should join the OGC.

    b. Establish New Zealand representation in ISO-TC59 SC13 - Organization and digitization of information about buildings and civil engineering works.

    c. Review possible involvement with other relevant standards organisations.

It is our belief that the advice contained in this document will provide the best way forward towards achieving common location standards that are of greatest utility for cross domain exchange of location information.

9 Appendix A - Glossary and acronyms

9.1 Glossary

Terms	Definitions
Austroads	The peak organisation of road transport and traffic agencies in Australia and New Zealand whose purpose is to support member organisations to deliver an improved Australasian road transport network.
Controlled vocabulary	An organised arrangement of words and phrases used to index content and/or to retrieve content through browsing or searching. It typically includes preferred and variant terms and has a defined scope or describes a specific domain.
Coordinate creep	Due to plate tectonics and other geological processes, real world coordinate values may change over time.
Digital twins	Closely related to BIM concepts, these provide a digital replica of a physical entity. By bridging the physical and the virtual worlds, data is transmitted seamlessly allowing the virtual entity to exist simultaneously with the physical entity.
Forward works viewer	An interactive web-based platform for stakeholders to observe active and planned works to aid coordination and planning and to enable the mitigation of spatial and traffic conflicts. Developed as a project within the LINZ led Canterbury SDI.
Integration	Allows a series of products to talk to each other in their current state, but also provides backwards and forwards compatibility with future versions of each product.
Interchange standard	Also known as exchange standard, provides a well-known, structured way of sharing data that may differ from internal storage. Supports interoperability.
Interoperability	Allows systems to work together in harmony in their existing state. These systems are loosely coupled with minimal requirements between functionally independent components.

Terms	Definitions
Local model coordinates	Used to model entities in a self-referential fashion with no connection to real world coordinates.
Location Reference Methods	A model-specific methodology for assigning unique references to a location.
Metadata	Structured information that describes, explains, locates or otherwise makes it easier to retrieve, use or manage an information resource.
Metamodel	Also known as a surrogate model, this is a model of a model. Metamodeling is the analysis, construction and development of the frames, rules, constraints, models and theories applicable and useful for modelling a predefined class of problems.
OGC Innovation Programme	Provides a collaborative agile process for solving geospatial challenges. Organisations (sponsors and technology implementers) come together to solve problems, produce prototypes, develop demonstrations, provide best practices, and advance the future of standards.
OGC Interoperability Experiment	OGC Interoperability Experiments are short duration, low-overhead, formally structured and approved interoperability initiatives led and executed by OGC members to achieve specific technical objectives that further the OGC Standards Baseline.
OGC Pilot	A type of OGC Innovation Program initiative, these apply and test OGC standards in real world applications using Standards Based Commercial Off-The-Shelf (SCOTS) products that implement OGC standards. Pilot projects are an opportunity for users to understand how to best address their requirements using standards-based architectures.
OGC Web Feature Service	An Open Geospatial Consortium standard that provides an interface allowing requests for geographical features across the web using platform-independent calls
Personas	Used in user-centred design and marketing to provide a fictional character to represent a user type that might use a product in a certain way.

Terms	Definitions
Profiles	In our context, an implementation of a standard that follows the guidance provided by ISO-19106:2004 Geographic information — Profiles
Registry	A semantic technology that provides a means to identify, declare and publish through item registration.
Request/Reply pattern	A message exchange pattern in which a requestor sends a request message to a replier system which receives and processes the request, ultimately returning a message in response. This is a simple, but powerful messaging pattern which allows two applications to have a two-way conversation with one another over a channel. This pattern is especially common in client–server architectures.
Taxonomies	A controlled vocabulary with a hierarchical structure, with the understanding that there are different definitions of a hierarchy. Terms within a taxonomy have relations to other terms within the taxonomy. These are typically: parent/broader term, child/narrower term, or often both if the term is at mid-level within a hierarchy.
Technical debt	A concept in software development that reflects the implied cost of additional rework caused by choosing a custom or easy solution now instead of using a better or more universal approach that may take longer or more effort.
Use case	A detailing of actions or event steps typically defining the interactions between a role and a system to achieve a goal.
User story	A part of the agile software development approach, these are short, simple descriptions of a feature told from the perspective of the person who desires the new capability, usually a user or customer of the system. They typically follow a simple template and represent a piece of work that can be completed in one iteration.
Web service standards	Provide an agreed upon method for data access, transmission, synchronisation, display and processing.

9.2 Acronyms

Acronym	Definition
3 Waters	The phrase commonly used in New Zealand to refer to the three municipal 'wet infrastructures' that provide drinking water, wastewater and stormwater services.
BIM	Building Information Modelling is a process supported by various tools, technologies and contracts involving the generation and management of digital representations of physical and functional characteristics of places.
BuildingSMART or bSI	Building Smart International is the worldwide industry body driving the digital transformation of the built asset industry. buildingSMART is committed to delivering improvement by the creation and adoption of open, international standards and solutions for infrastructure and buildings.
CAD	Computer-aided design is the use of software to aid in the creation, modification, analysis or optimisation of a design.
Canterbury SDI	Through the Canterbury Spatial Data Infrastructure (SDI) Programme, LINZ worked with Canterbury local and central government agencies to accelerate the recovery effort by enabling improved sharing and use of location-based information.
CORS	Continuously Operating Reference Stations are a network of GNSS sensors that provide a virtual base station which allows users to access long-range high-accuracy corrections to GNSS surveyed positions.
CRS	A Coordinate Reference System or Spatial Reference System is a coordinate-based local, regional or global system used to locate geographical entities. It defines a specific map projection, as well as transformations between different spatial reference systems.
Datex2	Hosted by CEDR (Conference of European Directors of Roads) DATEX II is the electronic language used in Europe for the exchange of traffic information and traffic data.
DIA	New Zealand Department of Internal Affairs

Acronym	Definition
e-GIF	Superseded by the GEA-NZ framework, the New Zealand e-Government Interoperability Framework was a scheme for ensuring the inter-operation of computer-based systems across all-of-government. It was intended to minimise problems arising from incompatible content of different computer systems.
ETL	Middleware often used in data warehousing practices - extract, transform, load (ETL) is the general procedure of copying data from one or more sources into a destination system which represents the data differently from the source(s) or in a different context than the source(s).
FME	Produced by Safe Software of British Columbia, Canada, the Feature Manipulation Engine (FME) is a broadly used data integration platform with support for spatial data.
GEA-NZ framework	The Government Enterprise Architecture for New Zealand framework provides an all-of-government view of how the system architecture needs to support strategic goals, policies and investments.
GML	Geography Markup Language is an XML grammar defined by the Open Geospatial Consortium to express geographical features. GML serves as a modelling language for geographic systems as well as an open interchange format for geographic transactions on the Internet.
GeoJSON	An open standard format overseen by the Internet Engineering Task Force (IETF) designed for representing simple geographical features, along with their non-spatial attributes. It is based on the JavaScript Object Notation. The features include points, line strings, polygons and multi-part collections of these types.
GNSS	GNSS stands for Global Navigation Satellite System and is the standard generic term for satellite navigation systems that provide autonomous geospatial positioning with global coverage. This term includes e.g. the GPS, GLONASS, Galileo, Beidou and other regional systems.
IMK	INSPIRE supported information model for cable and pipes Includes Flanders KLIP (The Flemish cable and guidance information portal) and KLIM (Cable and Leading Information Reporting Point).

Acronym	Definition
InfraGML	An implementation standard built on the OGC LandInfra conceptual model, this Encoding Standard presents the implementation dependent GML encoding of concepts supporting land and civil engineering infrastructure.
INSPIRE Directive	Aims to create a European Union spatial data infrastructure for the purposes of EU policies or activities which may have an impact on the environment. This European Spatial Data Infrastructure will enable the sharing of environmental spatial information among public sector organisations, facilitate public access to spatial information across Europe, and assist in policy making across boundaries.
ISO 19107	ISO TC211 standard that specifies conceptual schemas for describing the spatial characteristics of geographic features, and a set of spatial operations consistent with these schemas. It treats vector geometry and topology up to three dimensions. It defines standard spatial operations for use in access, query, management, processing and data exchange of geographic information for spatial (geometric and topological) objects of up to three topological dimensions embedded in coordinate spaces of up to three axes.
ISO 19125	ISO TC211 standard that establishes a common architecture for geographic information and defines terms to use within the architecture. It also standardises names and geometric definitions for Types for Geometry.
ISO 19166	The draft standard from ISO TC211 designed to support BIM to GIS conceptual mapping.
ISO 55000	An ISO TC251 international standard covering the management of assets of any kind.
ISO TC211	The International Organization for Standardization technical committee responsible for standardisation in the field of digital geographic information/geomatics.
ISO TC251	The International Organization for Standardization technical committee responsible for standardisation in the field of asset management.

Acronym	Definition
ISO TC59 SC13	TC59 is the International Organization for Standardization technical committee responsible for buildings and civil engineering works Subcommittee 13 is charged by TC 59 to focus on international standardisation of information through the whole life cycle of buildings and infrastructure across the built environment - Building Information Management (BIM).
LandInfra	A Conceptual Model whose scope is land and civil engineering infrastructure facilities. Jointly developed by buildSMART and OGC.
LINZ	Land Information New Zealand - traditionally leads the country's national geospatial strategy, survey and mapping, hydrology and land record keeping.
NZGD	The New Zealand Geographic Datum is the official datum used to define the positions of points in New Zealand. It relates the physical location of a point with a coordinate in terms of latitude, longitude and ellipsoidal height. The datum is designed to provide constant unchanging coordinates for features even though New Zealand is continuously moving and deforming under the influence of the Australian and Pacific tectonic plates across which it lies. To do this the datum itself is moving and deforming along with the New Zealand land mass - it is a 'plate-fixed' datum.
NZTA ADMS	A collaborative project between the NZ Transport Agency and the Road Efficiency Group (REG) the Asset Data Management System to improve the management of land transport infrastructure asset information, so as to make the best decisions about New Zealand's land transport assets.
NZTM	New Zealand Transverse Mercator 2000 (NZTM2000) is the projection used for New Zealand's Topo50 1:50,000 and other small-scale mapping. Spatial data users are encouraged to use NZTM2000 where a projection is required within mainland New Zealand.
OASIS	The Organization for the Advancement of Structured Information Standards is a global non-profit consortium which offers projects—including open source and open standards projects—a path to standardization and de jure approval for reference in international policy and procurement.

Acronym	Definition
OGC	The Open Geospatial Consortium is an international voluntary consensus standards organization encouraging development and implementation of open standards for geospatial content and services, sensor web and Internet of Things, GIS data processing and data sharing.
OpenLR	A royalty-free open standard for ‘procedures and formats for the encoding, transmission, and decoding of local data irrespective of the map’ developed by TomTom. The format allows locations localised on one map to be found on another map to which the data have been transferred.
PND	Personal Navigation Device
PipelineML	An OGC Conceptual and Encoding Model Standard that defines concepts supporting the interoperable interchange of data pertaining to oil and gas pipeline systems.
SCIRT	Now disbanded, the Stronger Christchurch Infrastructure Rebuild Team was an alliance between owner and non-owner participants formed with the purpose of rebuilding horizontal infrastructure in Christchurch following the earthquakes of 2010 and 2011. The owner participant organisations were: Canterbury Earthquake Recovery Authority, Christchurch City Council and New Zealand Transport Agency. The non-owner participants included: City Care, Downer, Fletcher, Fulton Hogan and McConnell Dowell. Many other Christchurch-based companies were also part of SCIRT, playing a vital role in delivering the SCIRT programme of work.
WFS-T	The OGC Web Feature Service - Transactions is a fully transactional Web Feature Service (WFS) which enables users to insert / delete / modify the available features.
WGS84	An Earth-centred, Earth-fixed terrestrial reference system and geodetic datum, WGS84 is based on a set of constants and model parameters that describe the Earth's size, shape, gravity and geomagnetic fields.

10 Appendix B - Survey

The survey was divided into two sections, Values and Challenges.

10.1 Values

Users were asked to indicate with a ranking of 1 to 10 (with 10 being high) the perceived value to their organisation to be gained through the adoption of common geospatial location standards. These can be thought of as the drivers that led their organisation to participate in this effort.

The values were categorised into the following groups:

10.1.1 Direct User Values

- Social Values
- Infrastructure / Operational Values
- Financial Values
- Strategic and Political Values.

10.1.2 Direct User Values (one only)

- Improved Data Availability.

10.1.3 Social Values

- Better decision-making ability
- Cross-agency coordination
- Reduced barriers to sharing information
- Institutional effectiveness
- Improved processes.

10.1.4 Infrastructure / Operational Values

- Ease of integration with other systems
- Improved international collaboration
- Public participation and accountability (Open Data)
- Inter-agency collaboration
- Reuse, adaptation and consolidation of systems and data
- Mainstreaming of GIS throughout organisation
- IT performance improvements.

10.1.5 Financial Values of Investment

- Total cost savings
- Total cost avoidance.

10.1.6 Strategic and Political Values

- Development of closer working relationships
- Supports improved decision making.

10.2 Challenges

These questions were posed to users to address the perceived challenges to implementing Geospatial Location Standards in their organisation. They generally required a yes/no response and an optional comment.

Challenges were divided into the following seven categories:

1. **Bureaucratic and management issues**

   a. Do there exist rules and institutional arrangements that seem likely to hinder adoption of these standards?

   b. Does a lack of formal obligations to require standards challenge implementation; be these legal, regulatory, contractual or other requirement?

   c. Is there sufficient awareness by your organisation's management of the value of these standards?

   d. Does there exist an adequate business case to support return on investment? Is the existing investment by the organisation in quality geospatial location data understood?

   e. Is your management comfortable in making funding available for building and curating data?

   f. Does management understand the skills, competencies and knowledge needed by the organisation in the geospatial domain now (and in the future)?

2. **Vendor issues**

   a. Does there exist a lack of support for these standards by your software and data vendors?

   b. Does your organisation currently use proprietary solutions that obfuscate the need to implement these standards?

3. **Privacy and security issues**

    a. Do your customers perceive issues with privacy, such as poor anonymisation of data?

    b. Are there corporate trade secrets or other organisational IP that is feared will not be protected?

    c. Do there exist public safety and security concerns with sharing data?

4. **Technical issues**

    a. Are there concerns around authentication regimes used in the sharing of data?

    b. Are there concerns that the old system supports your particular needs where new ones will not?

    c. Are there fears that a new system will change business processes and hinder business as usual?

    d. Does perceived difficulty to translate data to a new model create barriers?

    e. Are there concerns about availability of skilled personnel to support potential changes?

5. **Data issues**

    a. Are there concerns about the quality of digital data received and shared?

    b. Are there concerns that lack of documentation and metadata may hinder use of shared data?

6. **Cultural issues**

    a. Would the adoption of these standards face resistance expressed as 'reluctance to change' by members of your organisation?

    b. Do you believe that your Stakeholders may express resistance?

    c. Do you fear that your organisation may fail to understand relevancy? That there are more important things to address or that the chosen solution may make things worse?

    d. Is location data valued as a business asset by your organisation?

7. **Community issues**

    a. Is potential poor governance of your data sharing community a concern; be it in structure or execution - e.g. failure to meet, communicate, form agreements…?

b. Does your data sharing community have sufficient focus and commitment necessary to succeed?

c. Do sufficient cooperative agreements exist that guarantee a seat at the table for participants?

10.3 Compiled survey results

Colour Key - Organisation Type

Engineering Firm / Contractor
Local Government
Utility or Transport Company
National Government;

Values Survey Question Results

Category	Question	1	2	3	4	5	6	7	8	9	10	11	12	13	low	high	Ave.	Ave.	Ave.	Ave.	Ave.	Comments
Direct User Values	Improved data availability	8	10	7	10	10	8	10	10	8	10	8	10	9	7	10	9.08	8.33	10.00	10.00	8.50	Consistency in standards
																						Would assist greatly with collaboration for design and construction of our major infrastructure within the road.
																						We promote the use of common geospatial location standards as it benefits all users of the data, particularly when wanting a national view of separate regional datasets being managed by different organisations.
																						Informational linked to Geospatial views will be an important factor in a digital public service.
																						It is seen as valuable within the context of what is commercially viable for the business
																						Improved accuracy, reliability and interoperability of data
																						Will reduce costs in setting up new contracts And assist standardising asset as built handover processes
																						We have many contracts across NZ. Standardisation will make our technology solutions and improvements more cost effective
Social Values	Better Decision Making Ability	6	10	7	10	10	8	5	10	10	10	8	10	5	5	10	8.38	8.67	10.00	10.00	5.50	There is potential for LINZ to access this data and it would be much easier on many levels for the data to match a standard. This would be the same for any government organisation that might use this data.
	Cross-agency Coordination	10	10	7	10	10	10	10	10	10	8	8	10	7	7	10	9.23	9.33	10.00	9.33	8.50	Informational linked to Geospatial views will be an important factor in a digital public service and addressing social and environment issues.
	Reduced Barriers to Sharing Information	9	10	7	10	5	9	10	10	8	8	8	8	5	5	10	8.23	8.33	7.50	9.33	7.00	Our business relies on shared information to protect our assets and work safely around others assets. Due to the nature of our assets public safety is paramount.
	Institutional Effectiveness	8	10	4	10	5	9	9	10	10	9	9	10	9	4	10	8.62	8.67	7.50	9.67	8.50	
	Improved Process	10	10	5	10	5	9	10	5	10	9	9	10	9	5	10	8.54	8.83	7.50	8.00	9.50	
Averages		8.6	10	6	10	7	9	8.8	9	9.6	8.8	8.4	9.6	7			8.6	8.77	8.50	9.27	7.80	
Infrastructure / Operational Values	Ease of Integration with Other Systems	10	10	5	10	10	9	7	10	9	10	9	10	9	5	10	9.08	8.67	10.00	10.00	9.50	The data to use these standards should be published as open data, with the exception of asset management and commercially sensitive information. There is a huge benefit to all of NZ if the location data and basic attribution is published as open data.
	Improved International Collaboration	7	10	1	10	10	8	3	10	5	3	7	7	6	1	10	6.69	6.17	10.00	7.67	6.50	Some areas of benefit include location information, emergency services, defence, safety analysis, transport planning, intelligent transport systems. There is also an inherent benefit for all users of land transport data to use the same source data regardless of the level they are working at.
	Public Participation & Accountability (Open Data)	7	10	5	10	10	8	7	8	10	5	6	10	5	5	10	7.77	8.00	10.00	7.67	6.00	Informational linked to Geospatial views will be an important factor in a digital public service and increasing inter-agency collaboration.
	Inter-agency Collaboration	9	10	6	10	10	9	7	10	10	5	9	10	8	5	10	8.69	9.00	10.00	8.33	8.50	Standards allow better integration between systems of multiple organisations
	Reuse, adaptation, & consolidation of systems & data	10	10	6	10	5	9	10	10	10	9	10	10	7	5	10	8.92	9.17	7.50	9.67	8.50	
	Mainstreaming of GIS throughout Organization	10	10	7	1	5	9	7	10	10	10	9	10	6	1	10	8	9.17	3.00	10.00	8.00	
	IT Performance Improvement	5	10	7	1	5	8	6	6	9	8	8	1	7	1	10	6.23	7.00	3.00	8.00	6.00	
Averages		8.29	10.00	5.29	7.43	7.86	8.57	6.71	9.14	9.00	7.14	8.29	8.29	6.86			7.91	8.17	7.64	8.76	7.57	
Financial Value of Investment	Total Cost Savings	4	10	3	10		6	6	10	8	8	7	8	6	3	10	7.17	6.50	10.00	9.33	5.00	There will still be a cost to Councils for implementation but the returns And benefits will be realised in the long term
	Total Cost Avoidance	4	8	3	10		6	8	10	9	8	7	8	5	3	10	7.17	6.67	10.00	8.67	4.50	Potential of resource savings where open data is reused for addressing and topographic mapping purposes.
																						I have no idea.
																						It is not very easy to rank total cost savings or cost avoidance
																						Cost savings is a focus in all our business cases and that can relate to cost avoidance and reduced risk.
																						Indirect savings between organisations on data transfer could be significant
Averages		4.00	9.00	3.00	10.00		6.00	7.00	10.00	8.50	8.00	7.00	8.00	5.50			7.17	6.59	10.00	9.00	4.75	
Strategic & Political Values	Development of Closer Working Relationships	9	10	5	8	10	7	7	10	9	9	9	8	4	4	10	8.08	7.67	9.00	9.67	6.50	One common language and easier to make comparisons
	Supports Improved Decision Making	7	10	6	8	10	7	8	10	10	9	9	10	8	6	10	8.62	8.33	9.00	9.67	7.50	In terms of agencies working together to adress the challenges of the future geospatial is core to decisions affecting the environment, sea level rises, species protection.
																						Standardised approach facilitates more robust reporting across contracts enabling sharing of report solutions between contracts and clients
Averages		8	10	5.5	8	10	7	7.5	10	9.5	9	9	9	6			8.35	8.00	9.00	9.67	7.00	
Overall Ave.		7.38	9.80	5.36	9.09	8.71	7.71	8.00	9.63	8.92	8.59	8.14	8.98	6.87			8.22	7.97	9.03	9.34	7.12	

Concerns Survey Results																																	
Section	Question	1	2	3	4	5	6	7	8	9	10	11	12	13	#Y	#N	%Y	%N	#NA	#Y	#N	%Y	#Y	#N	%Y	#Y	#N	%Y	#Y	#N	%Y	Comments
Bureaucratic & Management Issues	Do there exist rules and institutional arrangements that seem likely to hinder adoption of these standards?	Y	N	N		Y	Y	N	Y	Y	N	Y	N	Y	7	5	58.3	41.7	1	2		**100.0**	3	3	50.0	1		100.0	1	2	33.3	Training and recruiting the right people with right skill sets and work ethic will be difficult particularly when salaries are are not commensurate and are below average.
	Does a lack of formal obligations to require standards challenge implementation; be these legal, regulatory, contractual or other requirement?	Y	Y	N		Y	N	N	Y	Y	N	Y	N	Y	7	5	58.3	41.7	1	2		**100.0**	2	4	33.3	1		100.0	2	1	66.7	This will be a challenge. The challenge also will be in implementation - if it is not policy or legislated, adoption of the standards will always be dependent on funds
	Is there sufficient awareness by your organisation's management of the value of these standards?	N	N	Y		N	N	N	Y	Y	Y	Y	N	N	5	7	41.7	58.3	1		2	**0.0**	3	3	50.0		1	0.0	2	1	66.7	This section doesn't really apply to LINZ here.
	Does there exist an adequate business case to support return on investment? Is the existing investment by the organisation in quality geospatial location data understood?	N	Y	N		N	N	YN	N	Y	Y	Y	Y	N	5	6	45.5	54.5	2		2	**0.0**	3	3	50.0		1	0.0	2	1	66.7	A management layer that sometimes seems to lacks expertise or understanding of the value of the fields and practices being managed so that rather than advocating or supporting the experts and practitioners they get in the way.
	Is your management comfortable in making funding available for building and curating data?	N	N	N		Y	N	YN	Y	Y	Y	Y	N	N	5	6	45.5	54.5	2		2	**0.0**	2	3	40.0	1		100.0	2	1	66.7	There is a lack of support and understanding for the value of location data presently but it is something that some people are coming to to grips with
	Does management understand the skills, competencies, and knowledge needed by the organisation in the geospatial domain now (and in the future)?	Y	Y	N		N	N	N	Y	N	Y	Y	N	Y	6	6	50.0	50.0	1	2		**100.0**	1	5	16.7		1	0.0	3		**100.0**	Our business is under regulatory control and funding pressure in 5 year allocations. planning for funding outside budget will require prioritisation against that constraint.
Vendor Issues	Does there exist a lack of support for these standards by your software and data vendors?	Y	N	N			Y	N	Y	N	N	Y	N	Y	5	6	45.5	54.5	2	2		**100.0**	2	4	33.3				1	2	33.3	This section doesn't really apply to LINZ here.
	Does your organisation currently use proprietary solutions that obfuscate the need to implement these standards?	Y	N	N			Y	N	N	Y	N	N	N	Y	4	7	36.4	63.6	2	2		**100.0**	2	4	33.3					3	**0.0**	Specialist software vendors all have bespoke solutions the key is data mapping between systems which can be complex due to industry variations
Privacy & Security Issues	Do your customers perceive issues with privacy, such as poor anonymization of data?	N	Y	N			Y	N	N	Y	N	N	N	Y	4	7	36.4	63.6	2	1	1	50.0	2	4	33.3				1	2	33.3	This section doesn't really apply to LINZ here.
	Are there corporate trade secrets or other organisational IP that is feared will not be protected?	N	Y	N			Y	N	N	Y	N	N	N	Y	4	7	36.4	63.6	2	1	1	50.0	2	4	33.3				1	2	33.3	Datasets will need to be reviewed on a case by case basis againt our security requirements.
	Do there exist public safety and security concerns with sharing data?	N	Y				N	YN	N	Y	N	Y	N	Y	4	5	44.4	55.6	3	1	1	50.0	2	2	50.0				1	2	33.3	It depends on the data being shared most councils have the majority of asset location data in the public domain already
Technical Issues	Are there concerns around authentication regimes used in the sharing of data?	N	Y	N	N		N		Y	Y	N	N	Y	Y	5	6	45.5	54.5	2	1	1	50.0	2	3	40.0		1	0.0	2	1	66.7	We have a lot of proprietary systems that have very specific integration standards. Changes may need to be factored in updgrades across many years.
	Are there concerns that the old system supports your particular needs where new ones will not?	Y	Y	N	N		Y	Y	N	N	N	N	N	Y	5	7	41.7	58.3	1	2		**100.0**	2	4	33.3		1	0.0	1	2	33.3	
	Are there fears that a new system will change business processes and hinder business as usual?	Y	Y	N	N		Y	N	Y	Y	N	N	N	N	5	7	41.7	58.3	1	1	1	50.0	2	4	33.3		1	0.0	2	1	66.7	
	Does perceived difficulty to translate data to a new model create barriers?	Y	Y	N	N		Y	Y	Y	Y	N	Y	N	Y	8	4	66.7	33.3	1	2		**100.0**	4	2	66.7		1	0.0	2	1	66.7	
	Are there concerns about availability of skilled personnel to support potential changes?	Y	Y	Y	N		Y	Y	Y	Y	N	N	Y	Y	9	3	75.0	25.0	1	2		**100.0**	5	1	83.3		1	0.0	2	1	66.7	
Data Issues	Are there concerns about the quality of digital data received and shared?	Y	Y	Y	Y		N		Y	Y	N	Y	Y	Y	9	2	**81.8**	18.2	2	2		**100.0**	4	1	80.0	1		100.0	2	1	66.7	It will be important for sufficient feature level metadata and dataset metadata to be an integral part of the data model to provide enough information to understand the data lineage over time. This will be particularly important if the deformation model is to be applied to the data.
	Are there concerns that lack of documentation and metadata may hinder use of shared data?	Y	Y	Y	Y		Y	Y	Y	Y	N	Y	Y	Y	11	1	**91.7**	8.3	1	2		**100.0**	6		**100.0**	1		100.0	2	1	66.7	
Stakeholder issues	Would the adoption of these standards face resistance expressed as "reluctance to change" by members of your organisation?	Y	Y	N	N		Y	YN	Y	Y	N	N	N	N	5	6	45.5	54.5	2	1	1	50.0	2	3	40.0		1	0.0	2	1	66.7	Some may be resistant due to perceived costs This is especially prevalent in smaller local authorities
	Do you believe that your Stakeholders may express resistance?	Y	N	N	N		Y	N	N	Y	N	Y	Y	Y	6	6	50.0	50.0	1	2		**100.0**	4	2	66.7		1	0.0		3	**0.0**	They do not cope with change well. It always comes with a variance cost.
Does the organization value data?	Do you fear that your organisation may fail to understand relevancy? That there are more important things to address or that the chosen solution may make things worse?	Y	Y	Y	N		Y	YN	Y	Y	N	N	Y	N	7	4	63.6	36.4	2	1	1	50.0	4	1	80.0		1	0.0	2	1	66.7	where a location standard exists, data transfer between stakeholders is simplified
	Is location data valued as a business asset by your organisation?	Y	Y	N	Y		N	Y	Y	Y	Y	Y	N	Y	9	3	75.0	25.0	1	2		**100.0**	3	3	50.0	1		100.0	3		**100.0**	GIS adoption over the last 10 years in this orgainsation has been steady. WE have a growing reliance on location data now. Therefore further adoption should be an easier sell.
																																Our organisation is not mature enough to realise data is an asset in itself.
																																Our operational work is targeted to specific sites - we need to be able to accurately identify them so we maintain the right service.
Community Issues	Is potential poor governance of your data sharing community a concern; be it in structure or execution - e.g. failure to meet, communicate, form agreements...?	Y	Y				Y		Y	Y	N	Y		Y	7	1	**87.5**	12.5	5	2		**100.0**	3		100.0				2	1	66.7	
	Does your data sharing community have sufficient focus and commitment necessary to succeed?	N	Y				Y		N	YN	Y	N		N	3	4	42.9	57.1	6		2	**0.0**	1	1	50.0				2	1	66.7	
	Do sufficient cooperative agreements exist that guarantee a seat at the table for participants?	N	N				N		N	N	Y	Y		N	2	6	25.0	75.0	5		2	**0.0**	1	2	33.3				1	2	33.3	

11 Appendix C - Spreadsheet of user stories

This is the e-Spatial supplied spreadsheet (e-Spatial, 2019) with additional standards recommendations and comments by OWL.

Colour Key - Organisation Type

Engineering Firm / Contractor
Local Government
Utility or Transport Company
National Government

Num	User Story	Applicable Standard	OWL - Additional Standards	OWL - Comments
1.	**Geolocation and Linear Referencing User Stories**			
1.1	As an Asset Manager I want to have a NZTA asset register populated with accurate locations so that we and know where our assets are. (LR is not accurate enough and changes over time)	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	Austroads, LINZ ULS	
1.2	As an Asset Manager I want to be able to integrate different data sets (e.g. crashes, bridges, conditions of roads) so that NZTA can report on assets over time	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	Austroads, LINZ ULS	With GIS

Num	User Story	Applicable Standard	OWL - Additional Standards	OWL - Comments
1.3	As an Asset Manager I want to be able to store absolute locations to +/- 1m so that they can be shared and integrated in an automated and standardized way	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access		
1.4	As an Asset Manager I want to be able to take capital project as-built information and put directly into various asset information registers (without translating to a route position) so that no information is lost	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	GSS, LandInfra, ISO 55000	
1.5	As an Asset Manager I want to be able to store lines and polygons in their native geometry (can't have curved barriers or rest areas only points no geometry stored with it) so that NZTA has an accurate representation of the SH centreline	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access		Is this CAD or GIS?
1.6	As an Asset Manager I want to be able to use the underlying spatial entities (parcels) so that NZTA can value land accurately.	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	LADM	

Num	User Story	Applicable Standard	OWL - Additional Standards	OWL - Comments
1.7	As an Asset Manager I want to have a standard that clearly defines the location of an asset on or adjacent to the network including the offset along the linear path reference point (+ and -) , laterally and vertically so that I can correctly define the location of assets.	19148 - GI - Linear Referencing		
1.8	As an Asset Manager I want to be able to have a standard that provides conversion between linear and spatial so that a linear reference point on the network can be visually represented in conjunction with the spatial data	19148 - GI - Linear Referencing		
1.9	As an Asset Manager I want to have one road centreline for the entire country so that it can be crossed reference so that everyone who does work on the network has the same location regardless of what system they are using	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	GSS	
1.10	As an Asset Manager I want to be able to locate an asset along a local road so that the field crews can find the asset efficiently without spending time working out where they are	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access		Support for GNSS?

Num	User Story	Applicable Standard	OWL - Additional Standards	OWL - Comments
1.11	As an Asset Manager I want to capture an asset in a standardized format (WGS84 or NZTM (not local circuit)) so that it can easily be easily used in other systems	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access		
1.12	As an Asset Manager I want to see as little conversion as possible between data sets so that we don't lose data integrity	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access		Pattern - Store data in native format - convert JIT
1.13	As an Asset Manager I want to have the ability to check the road centreline accuracy so that it can be centrally managed and maintained. (Currently well managed for SH but not local roads)	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	GSS	
1.14	As a Geospatial Manager I want to capture and maintain roading assets in a GIS environment and export to LR so that they are accurately located	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	Dynamic segmentation,	NZTM coordinates on LR
1.15	As a Geospatial Manager I want to have better than 0.5m accuracy for water and road assets so that the assets will be correctly located for maintenance and fault repairs (e.g. parking metres)	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	LINZ ULS	

Num	User Story	Applicable Standard	OWL - Additional Standards	OWL - Comments
1.16	As a Geospatial Manager I want to have better than 0.5m accuracy for water and road assets so that they can be integrated with water services networks (currently have 25-30m errors coming out of RAMM)	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	LINZ ULS	
1.17	As a Geospatial Specialist I want to be able to convert linear to geospatial and vice versa so that no data accuracy is lost in translation	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access, 19148 - GI - Linear Referencing	Dynamic Segmentation?	
1.18	As a Geospatial Specialist I want to enter assets using their geographic location so that when the road is realigned the assets will still be in the correct geographic location	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access		Geospatial First
1.19	As a Geospatial Specialist I want to enter assets using their geographic location so that when a new road or roundabout is added the assets will still be in the correct geographic location	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access		Geospatial First

Num	User Story	Applicable Standard	OWL - Additional Standards	OWL - Comments
1.20	As a Geospatial Specialist I want to be able to store assets and zones (e.g. urban / rural, no fly, speed limit zones) geospatially so that I can have multi-layer zone overlays	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access		
1.21	As a Planner I want to view my design in a GIS and maintain the attributions of my design so that I can see my design in the context of other geospatial features	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	LandInfra	
1.22	As an Industry Facilitator I want to in 10 years' time, have complete confidence that utilities are located accurately so that they intersect with other infrastructure in the correct location	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	LINZ ULS	
1.23	As an Investment Manager I want to have the exact geographic location of where an area or point fault occurs so that we can identify the fault easily and manage it for future repair work	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access		LR to Geospatial
1.24	As an Investment Manager I want to be able to translate between the linear referencing and the geographic coordinates so that when field crews are dispatched, they can easily find the location, inspect the site and record the work	19148 - GI - Linear Referencing		LR to Geospatial

Num	User Story	Applicable Standard	OWL - Additional Standards	OWL - Comments
1.25	As an Investment Manager I want to be able to record the fault in the correct geographic position so that I can accurately see where the fault occurs so that it can be easily found for inspection or maintenance.	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access		LR to Geospatial
1.26	As an Investment Manager I want to at a national level, calculate the road length in a standard way so that NZTA has an accurate and persistent representation of the road network in NZ.	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access		But what standard?
2.	**3D / Z value User Stories**			
2.1	As an Asset Manager I want to collect x, y, z, values for all assets so that we can model them in 3D	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	LandInfra CityGML BIM	
2.2	As an Asset Manager I want to record the x, y and z value of an asset so that I can visualise them in 3D	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	LandInfra CityGML BIM	

Num	User Story	Applicable Standard	OWL - Additional Standards	OWL - Comments
2.3	As a Geospatial Manager I want to be able to incorporate 3D models into GIS so that we can perform 3D analysis	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	LandInfra CityGML BIM	
2.4	As a Geospatial Manager I want to be able to store the 3D (z value) so that it represents real world values as heights are critical to water networks	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	LINZ ULS	
2.5	As a Geospatial Manager I want to convert all existing vertical data to NZVD2016 so that one datum is used across the entire country so that height data can be compared nationally	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	LINZ ULS	
2.6	As a Geospatial Manager I want to record the x, y and z along a cross section on a river so that we can establish the deepest point of river	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access		
2.7	As a Geospatial Manager I want to record the z value of the inlets and outlets of the manhole so that connectivity and manhole condition can be confirmed	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	LINZ ULS	

Num	User Story	Applicable Standard	OWL - Additional Standards	OWL - Comments
3.	**Coordinate Reference Systems User Stories**			
3.1	As a Geospatial Manager I want to be able to have interoperability between different coordinate systems so that it makes it easier to cross analyse different data sets	ISO 19111: Referencing by coordinates		
3.2	As an Investment Manager I want to change the coordinate system so that I can view NZ roads spatially in Excel to see where NZTA is spending money in a network view	ISO 19111: Referencing by coordinates		
4.	**Accuracy User Stories**			
4.1	As an Asset Manager I want to be able to store assets to +/- 1m so that NZTA can identify invisible (subsurface, skid resistance) assets	ISO-19157 - GI - Data Quality (Depends on business process)	LINZ ULS	
4.2	As a Geospatial Specialist I want to know at what accuracy data is captured so that I can understand its fit for purpose	ISO-19157 - GI - Data Quality (Depends on business process)	LINZ ULS	Metadata
4.3	As an Investment Manager I want to record the position and extent (measurement and position) of the fault accurately to at least (0.1 of a metre) so that the sum of the widths of the road corridor equals the standard width of a NZ road (20.1 m)	ISO-19157 - GI - Data Quality (Depends on business process)	Not a data quality issue. A resolution issue	

Num	User Story	Applicable Standard	OWL - Additional Standards	OWL - Comments
5.	**BIM User Stories**			
5.1	As an Asset Manager I want a BIM model that can be interchanged between all infrastructure owners so that it will make data exchange easier	ISO-19166 BIM to GIS (Under Dev)	IFC Codes.	Is GIS even needed?
5.2	As an Asset Manager I want to see the detailed engineering design in a geospatial environment so that I can understand the context of the design	ISO-19166 BIM to GIS (Under Dev)	LandInfra	
5.3	As a Geospatial Manager I want to be able to incorporate BIM models into GIS so that the model can be made available to everyone in the business and its use maximised	ISO-19166 BIM to GIS (Under Dev)	LandInfra	
5.4	As a Geospatial Specialist I want to be able to import asset information (BIM models, LiDAR, Drones) into a GIS so that we can integrate with spatial data to perform spatial analysis	ISO-19166 BIM to GIS (Under Dev)		FME GIS
5.5	As an Industry Facilitator I want to be able to have interoperability between BIM models and GIS so that we can utilise the full value BIM models for an integrated transport system	ISO-19166 BIM to GIS (Under Dev)	LandInfra	FME

Num	User Story	Applicable Standard	OWL - Additional Standards	OWL - Comments
6.	**Interoperability User Stories**			
6.1	As an Asset Manager I want to have a consistent schema that's compatible across the industry and agencies which will work for public transport, state highways and rail so that organisations can publish and make data quickly available and updateable on a spatial viewer.	ISO-19136: GML, ISO 19142: WFS, ISO 19128: WMS, OGC WMTS		
6.2	As an Asset Manager I want to be able to produce reports using geospatial data that we can visualize consistently from different sources so that can see all information in context regardless of the source	ISO-19136: GML, ISO 19142: WFS, ISO 19128: WMS, OGC WMTS		
6.3	As a Geospatial Manager I want to be able have Json and rest protocols for transferring data over web services so that it is more in-line with the IT web industry (which is web and JSON based) and easier to use.	ISO-19136: GML, ISO 19142: WFS, ISO 19128: WMS, OGC WMTS	19168 OGC API Features	
6.4	As a Geospatial Specialist I want to see Esri's rest APIs, Json, GeoJson, and database connections included in a standard so that NZTA can easily integrate data sets.	GI Web Standards 406	407	408

Num	User Story	Applicable Standard	OWL - Additional Standards	OWL - Comments
6.5	As a Planner I want to be as open and OGC compliant as possible to provide certainty that processes that I am connecting with, developing and making available to others are interoperable as possible so that we can build with confidence and without redundancy (will retain its value if built on open standards)	ISO-19136: GML, ISO 19142: WFS, ISO 19128: WMS, OGC WMTS		
7.	**Temporal User Stories**			
7.1	As an Asset Manager I want to be able to track the historic position of linear referenced events so that we have a record of where the events took place in time	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access	O&M?	
7.2	As an Asset Manager I want to see the history of the asset so that we can make good decisions about future work	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access		Versioning?
7.3	As a Geospatial Specialist I want to be able to track the history of linear referenced assets so that the assets do not disappear when the roads are deleted	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access		

Num	User Story	Applicable Standard	OWL - Additional Standards	OWL - Comments
7.4	As an Investment Manager I want to be able to look at what has happened on the network historically so that NZTA and the councils can analyse trends in their own network.	ISO-19107: Spatial schema, ISO-19125: Simple Feature Access		
8.	**Open / International User Stories**			
8.1	As an Asset Manager I want to have a standard that is understood and easily implementable by software vendors so that it has a good uptake rate.	Inherent in ISO standards		
8.2	As an Industry Facilitator I want to have open standards available so that that it removes barriers for industry and increases opportunities for coordination, innovation and releases value to the industry as a whole.	Inherent in ISO standards		
8.3	As a Planner I want to use international standards so that we can compare with overseas cities who are on a similar path	Inherent in ISO standards		
9.	**Governance User Stories**		Not really about governance	
9.1	As a Geospatial Manager I want to have a low barrier of entry to the standards and make sure they are fit for purpose (needs to be defined) so that the entire industry adopts the standards			

Num	User Story	Applicable Standard	OWL - Additional Standards	OWL - Comments
9.2	As a Geospatial Specialist I want to see an agency wide uptake of the standard so that there's a standard adhered to regarding transport data.			

12 Appendix D - Standards process

ISO TC211 follows the Model Driven Architecture Guide from Object Management Group. Model Driven Architecture (MDA) Guide Rev. 2.0; Object Management Group: Needham, MA, USA, 2014.

Requirement 4 in ISO 19103 states that a model shall have documented a clear description of its level of abstraction (International Organization for Standardization, 2015). ‘Level of abstraction’ refers to the amount of detail captured in a model and how specific that detail is to a particular implementation. Models may range in abstraction from definitions of the underlying patterns in modelling to definitions of concepts, through to platform-specific implementation specifications.

12.1 Standards

Four main levels of abstraction for standards are described in ISO 19103:

1. Metamodels - Most abstract - metamodels like the General Feature Model from ISO19109 and the UML Metamodel from ISO 19505 (International Organization for Standardization, 2012[b]).
2. Conceptual Schema - Abstract Schema - independent of any implementation technology (Core models with basic concepts, i.e. geometry and topology from ISO19107 (International Organization for Standardization, 2003)
3. Conceptual Schema - Application Schema - (Still conceptual models, but specific for applications, i.e. roads, buildings).
4. Implementation Schemas (Schemas for specific implementations, i.e. GML application schemas (XSD)

The lower the level, the greater the need for consensus. The higher the level the more flexibility to change.

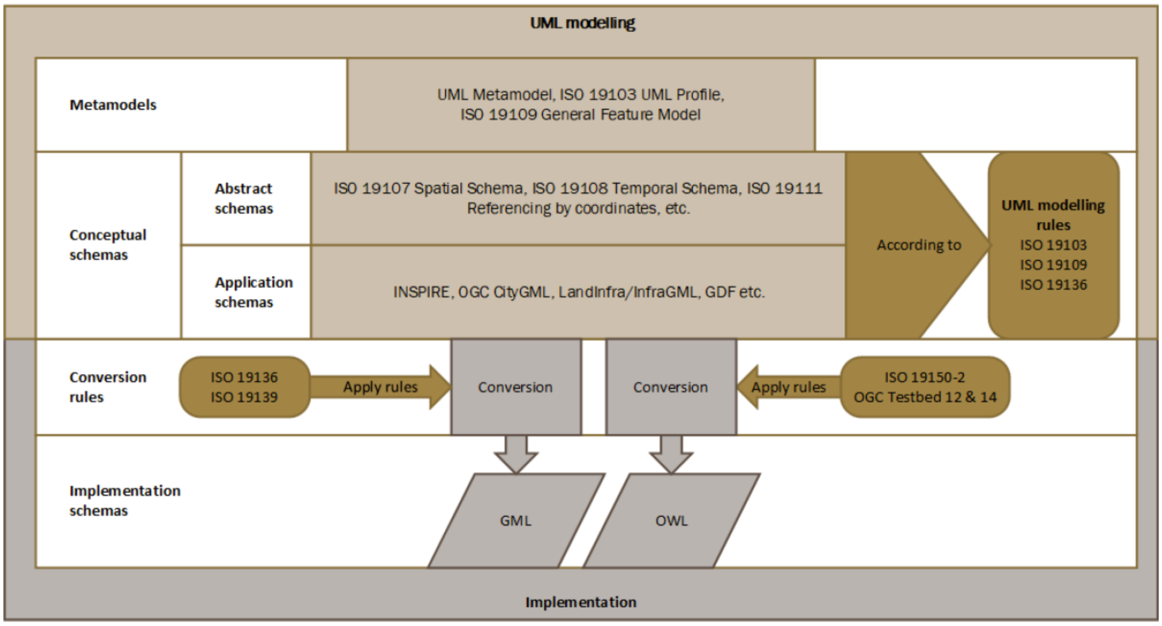


Figure 13: Abstraction of Standards

12.1.1 Metamodel

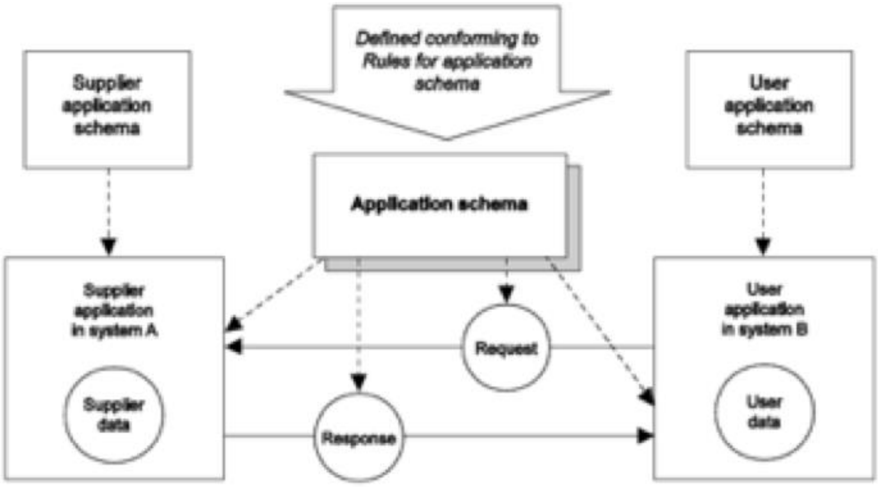
A metamodel standard is a model of the model, i.e. a simplified model of an actual model of a standard, system, or software-like entity. They provide the foundations upon which other standards are built.

12.1.2 Conceptual schemas

Conceptual schemas standard are kept independent of any implementation technology but can be converted to implementation schemas in database and exchange formats. A conceptual schema or conceptual data model is a map of concepts and their relationships. They provide the model that describes how different entities relate.

12.1.3 Application schema

In the context of geographic information and ISO/TC 211 vocabulary, an application schema standard consists in an application level conceptual schema rendering to a certain level of detail a universe of discourse described as data. Such data is typically required by one or more applications. Typically, additional information not found in the schema is included in a feature catalogue to semantically enrich the schema. Levels of details regarding schemata (models) and catalogues (data dictionaries) are described in the cross-references.



NOTE The unbroken lines show the flow of data. Broken lines denote the role of the application schema on the data interchange.

Figure 14: Data interchange by transaction

Figure 15: Data interchange by transfer

12.1.4 Implementation schema

An application schema is intended for implementation, for example as a GML application schema or relational database schema. Implementation schema standards are characterised by the addition of application specific characteristics as properties of features, and the addition of other elements such as provenance or lifecycle management metadata (Groffen, Shorter & Atkinson, date). Figure 16 illustrates of the different levels of abstraction.

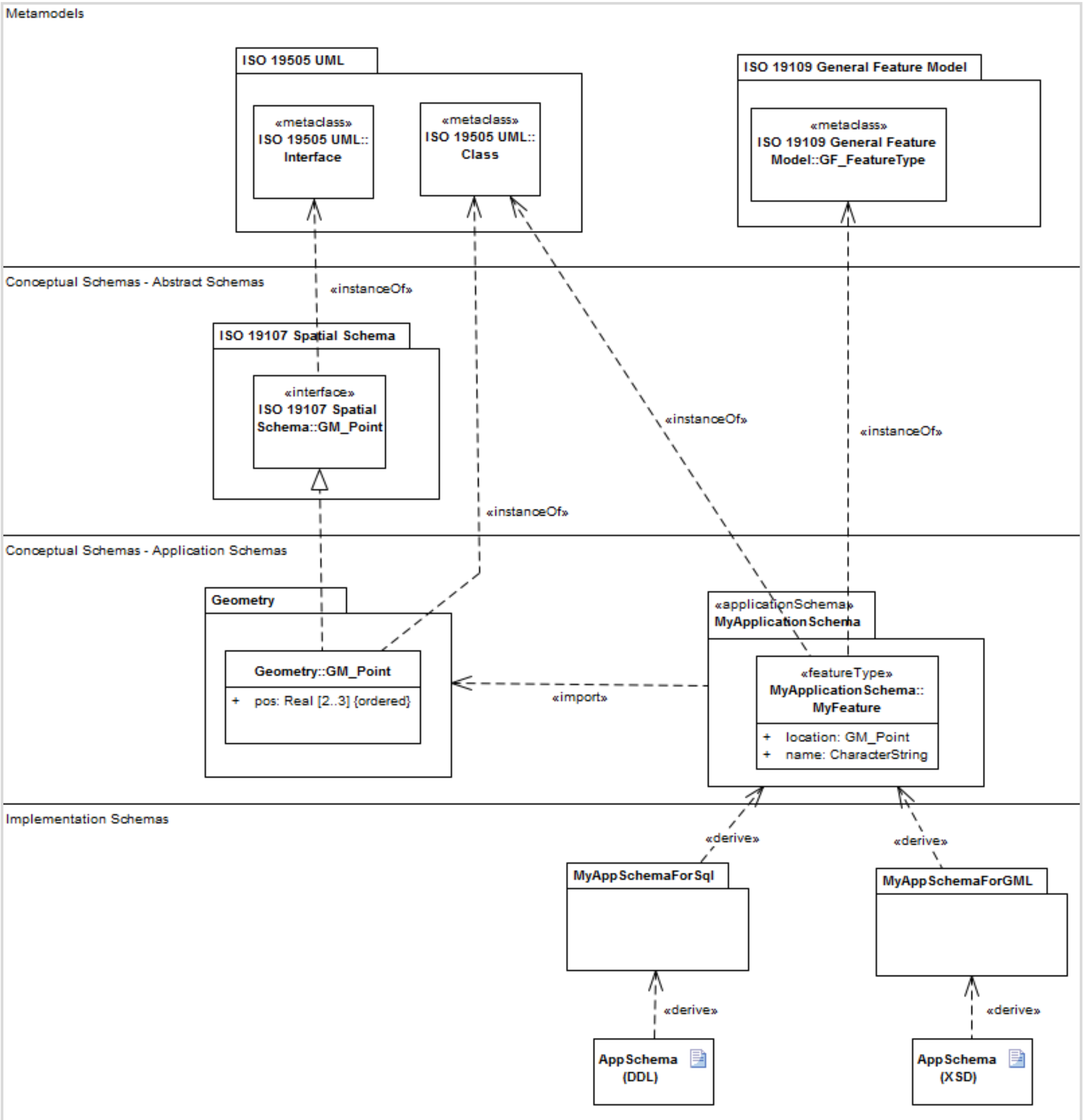


Figure 16: Different levels of abstraction

12.2 Uniclass hierarchy

The scope or universe of discourse that our model includes needs some definition in order to progress. The Austroads discussion of Uniclass hierarchy describes this issue. The distinction of views - particularly those of Designers vs Constructors as discussed elsewhere in this paper, well illustrates the distinct world views that different domains hold.

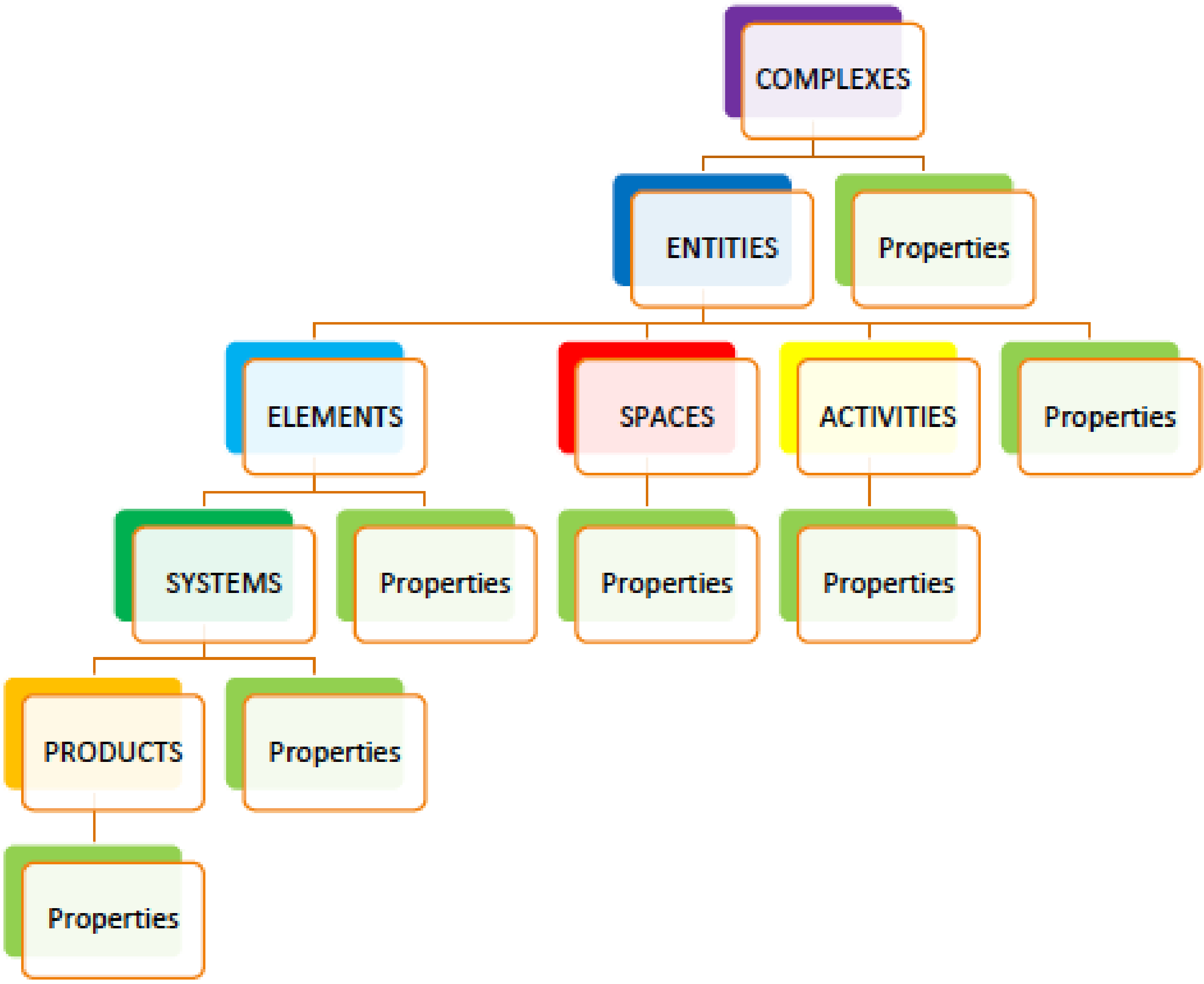


Figure 17: Uniclass 2015 hierarchy of physical object classes.

> The Uniclass 2015 hierarchy runs from Complexes (equivalent to sites defined by an ownership boundary) down to Products (which may be simple things like bricks, or complicated things like fans). Each level can be broken down into its Properties (describing the required or actual performance of the object) and its required or actual composition. Entities (such as buildings, bridges and tunnels) can be described in terms of their component Activities (the client or briefing view), Spaces (the design view) or Elements (the construction view). These three views of Entities are linked using Space Data Sheets, which can be used all through the asset lifecycle.
>
> Designers typically start at the top of the hierarchy and work their way down, making ever-more-detailed design decisions. Alexander et al (1977) illustrates this idea very well. Constructors start at the bottom of the hierarchy, assembling Products into Systems (the job of trades or subcontracts) and so on, until the entire Complex (everything within the site or project boundary) has been constructed.

Future model development needs to address the hierarchy of standards referenced and used, from Metamodels to Implementation standards (see Appendix D). Well described support for data interchange between LRMs is critical to success of an implementation model. At the application level this may be addressed for now by tools like FME, but the aim should be to reduce the need for such middleware. The model should also consider how the resulting standards will be compatible with other major systems with which it will be required to interact.

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