Towards an international address standard

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Abstract

Address standards have been developed and are still being developed by a number of countries (e.g. South Africa, Australia, New Zealand, United Kingdom, Denmark and the United States of America) and international organizations (e.g. Universal Postal Union (UPU), International Organization for Standardization (ISO) and the Organization for the Advancement of Structured Information Standards. (OASIS)). More recently, these standards have tended to include geospatial components and to cater for other forms of service delivery and not just postal, such as goods delivery, connecting utilities, routing emergency services and providing a reference context for presenting other information. The time is right for bringing these various initiatives together to develop one, common international address standard.

Such a standard will promote interoperability and reusability of address-related software tools, by providing one common framework for their developers. The standard will facilitate the development of spatial data infrastructures (SDIs), particularly those that span national borders, and facilitate data discovery through geospatial portals. An international address standard will help developing countries without widespread addressing systems speed up the process of assigning addresses and maintaining address data bases.

An international address standard will have significant benefits for global business as well as for government and international organizations. For example, a common standard would improve address management and quality for online retailers and courier companies that deliver all over the world. Also, a standard enables seamless access to address information across regional and national boundaries, which is vital in disaster management and emergency situations.

We present here a comparison of current address-related standards, highlighting their commonalities and differences. Drawing from current experiences with these standards, we highlight the benefits of an international address standard to the economy, society and governance. Finally, we explore the different options for developing such a standard and propose a potential scope for the standard.

Keywords: address data, standards, SDI

1. INTRODUCTION

1.1 Address standards

Address standards have been developed and are currently being developed by a number of countries and international organizations. These include Australia and New Zealand (as a joint effort), Denmark, South Africa, the United Kingdom, the United States of America, the Universal Postal Union (UPU), the International Organization for Standardization (ISO) and the Organization for the Advancement of Structured Information Standards (OASIS). While the UPU standard (UPU S42 2006) narrowly focuses on postal addresses, and the OASIS standard on customer addresses with geospatial coordinates, the national standards have tended to cater for all forms of service delivery over and above mere postal delivery and these national standards regard an address as a stand-alone geographic feature. This notion of an address being more than a set of directions for delivering post is reflected in the address definitions presented in Tables 1 through 10 in Section 3, which provide information about existing address standards. The focus in these standards is on addresses for a wide range of public and private service delivery which includes anything from utility services such as water, sewerage, telecommunications and electricity supply; refuse collection; billing; postal and courier (e.g. Fedex, UPS) delivery; to emergency dispatch/response; goods delivery; serving summonses; household surveys; land and property registration; and simply visiting friends.

Addresses are also critical for services that are not necessarily performed at the address, such as for rates and taxes, opening bank accounts or buying on credit, obtaining an identity document or passport, voting, and obtaining employment (Coetzee and Cooper, 2007b). In some countries the requirement for an address is explicitly written into the legislation, as in three South African Acts: the Financial Intelligence Centre Act (FICA), the Identification Act and the Electoral Act. In other countries this requirement is implicit through a personal identification number, assigned to a child at birth in Denmark, for example, and to open a bank account, obtain a passport or social security card or vote for elections, one also needs to have a registered address in the Danish Civil Registration System.

The origin and purpose postal vs. non-postal address standards has influenced the content of these standards. Postal address standards were originated to support:

1. Creation of master address lists, against which input addresses can be matched.
2. Rules for standardization of input addresses for matching against the master list.
3. Rules for formatting addresses (including abbreviations) so they fit on a mail piece and can be readily interpreted by mail sorters.
4. Rigorous definition of address syntax only to the level of mailing address "lines".

On the other hand, geo-enabled address standards for *all* kinds of delivery support the creation and management of address reference databases. As such they extend postal standards by requiring provision for:

1. *All* kinds of addresses (not just those for postal delivery).
2. Systematic definition of all address elements and syntaxes that are required

to decompose addresses into spatial features and/or normalized relational database tables, and to reconstruct address records from those spatial features and/or tables.

3. A unique address ID for each address.
4. Relating addresses to coordinates.
5. Address metadata, including record-level metadata such as the status (future, active or retired) and period during which the address was/is in use.
6. Systematic address data quality testing, error-trapping, and anomaly identification, including compilation of the local address assignment rules into an address schema.
7. Specification of encoding formats such as XML that enable electronic data exchange between different institutions.

1.2 Addressing as a reference system

A spatial reference system is used to identify locations on the surface of the Earth, and there are three types of reference systems:

1. a *coordinate reference system* specifies the location by reference to a datum;
2. a *linear reference system* specifies the location by reference to a segment of a linear geographic feature and distance along that segment from a given point; and
3. a *geographic identifier reference* system specifies the location by a label or code.

As per ISO 19112, - *Geographic information - Spatial referencing by geographic identifiers*, a geographic identifier reference system comprises a related set of one or more location types, that may be related to each other through aggregation or dis-aggregation, possibly forming a hierarchy. An example of such a geographic identifier reference system in South Africa would be *Country* > *Province* > *Municipality* > *Suburb*. ISO 19112 further describes a gazetteer as a directory of instances of location types in a spatial reference system, in other words *South Africa* > *Gauteng* > *City of Tshwane Metropolitan Municipality* > *Hatfield* is a location instance of the reference system above.

The similarity between a geographic identifier reference system and an addressing system can be illustrated by extending the geographic identifier reference system above to include street names and street numbers, as in *Country* > *Province* > *Municipality* > *Suburb* > *Street* > *Street Number*. Now an address can be represented as a location instance of this reference system: *South Africa* > *Gauteng* > *City of Tshwane Metropolitan Municipality* > *Hatfield* > *Pretorius Street* > *1083*.

The British address standard, BS 7666, was developed in line with this notion of a geographic identifier reference system. BS 7666 views ISO 19112 as an overall set of guidelines and defines a specific class of geographic identifiers, namely addresses. The specific implementation of BS 7666, the National Land and Property Gazetteer (NLPG), holds addresses of all fixed man-made properties including residential units, commercial units(shops offices warehouses etc), points of interest (monuments, parks etc), leisure units (swimming pools, clubs, pubs etc) and other infrastructure such as railway stations, piers, canals, public conveniences, telecom masts etc.

However, if address numbers are assigned according to distance, then thoroughfare addressing can be regarded as a type of linear referencing system, as opposed to a geographic identifier reference system. For example, if address numbers are increased at one per meter, then "310 King Street" means: "Proceed 310 meters along King Street from its beginning, then look to the even-numbered side of the street.", i.e. route, reference point, distance, offset.

In the extreme case, addressing can even resemble a coordinate reference system. For example, in South Africa addresses in remote rural areas are captured as "dots" either with GPS devices or from aerial photography. Each one of these dots represents an address. The geographic identifiers associated with the dot could include the province, municipality and village name, but no more than that. To locate the address, one has to know the coordinate. Over time theses addresses could evolve into addresses as we more commonly know them, with street names and numbers.

Thus, one could consider addressing to fall into all three types of reference systems, or consider addressing to be a fourth type of reference system, since there could be a many-to-many relationship between an address and what is being addressed, e.g. a building or a land parcel.

1.3 Level of maturity of understanding of addresses

While the South African and US address standards are still under development (Coetzee, 2006), the Australian/New Zealand, Danish and British standards have been implemented in their respective countries, indicating that in these countries, address standardization has already progressed on the route towards maturity where maturity refers to the level of understanding of addressing systems, addresses and address data. A US postal addressing standard has a long history in the country, resulting in a high level of maturity for postal address standardization.

In Denmark a nationwide common address format was introduced as a *de facto* standard, with the implementation of the Danish Civil Registration System as early as 1968 (Lind, 2004). In the following 25 years, the standard was enforced and taken into use in the public Building and Dwelling Register, in the first generation of digital large-scale topographic maps, and in the Danish Business Register. The Danish address standard is now enabling the joint use of the address system for both registration and statistics about all citizens, properties, dwellings (households) and business entities.

The US postal addressing standard (USPS Publication 28) was set forth twenty years ago and has been widely accepted and implemented with few changes since. The USPS standard has been the foundation for every US address standard since, including the Content and Classification parts of the *Draft Street Address Standard* that is currently in preparation under sponsorship of the United States Federal Geographic Data Committee.

Historically in the UK a notional standard for addresses based on the needs of the postal delivery service had been adopted and used wherever address data has been held. Recognizing the limitations of this approach in both technical and practical terms when applied to the wider geographic non-postal world, in 1995 local government started working towards a national land and property gazetteer based on a British Standard. This standard was reviewed and its relevance and applicability confirmed in 2000 and 2005. The latest review has brought the standard in line with ISO 19112 - *Geographic information - Spatial referencing by geographic identifiers* and includes a new general section which provides a common structure for the creation of gazetteers of any class of geographic object.

The specific implementation of this standard within local government calls for each local authority (376 in England and Wales and 32 in Scotland) to create and maintain a local gazetteer of all land and property within their administrative area for which they have statutory obligations in relation to planning and development control and street naming and numbering. Data entry conventions have been agreed and contractual relationships and timetables have been set to ensure that gazetteers to a common standard are available. These standardized gazetteers have been combined into a national dataset that has grown in quality and sophistication since 2001.

The National Land and Property Gazetteer (NLPG) covers England and Wales and comprises 27.8 million property records with over 29.3 million associated addresses. Underlying this project is a definitive street gazetteer containing details of 1.5 million records. A similar project in Scotland is also approaching maturity.

The benefits of the standards based approach in terms of efficiency, revenue protection and better service provision have been increasingly recognized and realized at the local level despite initial opposition and skepticism that owed much to a "silo mentality" within individual departments. A national extension of this mentality, with the additional constraint of commercial interests, has delayed the widespread adoption of the locally created nationally consistent solution albeit with notable exceptions amongst the emergency services.

At the local level the best examples of the application of the standard address base are the increasing number of web based one-stop shops offering the citizen access to information on all of the services provided by local government via a variety of address based search engines.

Address standards activity has been building at the national level in a variety of countries in response to increasing demand for unambiguous addresses, the development of national address databases, and as required by service-oriented economies to deliver services. Generally, this requires all address elements (e.g. street names) to be spelled correctly; to be associated correctly with area geographies and postal codes and to be unique within them; and to be geocoded (linked to geographical coordinates). In some cases that also requires linear referencing, that is, knowing the location described by the address in relation to a network (road, pipeline, power line, etc). Address information must be interchangeable to answer *all* these needs. National standards that have been developed to meet these increasing demands have already done much of the basic work of defining all aspects of addresses, thus raising the maturity level of address information.

This level of maturity in the understanding of addressing systems, addresses and address data is an important consideration in the timing of a standard: the technology and design space should be sufficiently mature to ensure that the standard provides an optimal solution. If a standard is produced too early in the cycle, there is not enough knowledge to produce a good standard (Blanchard, 2001).

1.4 ISO address-related standards

The International Organization for Standardization's Technical Committee ISO/TC 211, *Geographic information/Geomatics*, has developed two International Standards for spatial referencing, that is, for specifying where something is:

- ISO 19111:2007, *Geographic information – Spatial referencing by coordinates*: this standard describes the structured metadata (that is both human and computer readable) required for using coordinates, covering coordinate systems, coordinate reference systems and coordinate transformations, as well as types of coordinates.
- ISO 19112:2003, *Geographic information – Spatial referencing by geographic identifiers*: this standard describes how to link something to a location without explicitly using coordinates, but through a relationship to a location defined by a geographical feature (i.e. something with a name or identifier).

While computers might 'prefer' addresses expressed as coordinates, for human use, an address should be a form of spatial referencing by geographic identifiers, i.e. containing intelligible names and context, such as a hierarchy of names (e.g. street, suburb, town, province and country). Address-related standards that have been developed by ISO include:

- ISO/TC211 has also developed ISO 19133:2005, *Geographic information – Location based services – Tracking and navigation*, which includes an address model to describe a location for tracking and navigation that is acknowledged to be tentative.
- Previously, ISO/TC 154, Documents and data elements in administration, commerce and industry, in collaboration with the UPU, had developed ISO 11180:1993, *Postal addressing*, but this standard was only for the dimensions and location of the postal address on forms, and was withdrawn in 2003.
- ISO/TC211 is currently developing ISO 19148, *Geographic information – Location based services – Linear referencing*, which will prescribe the data and services needed to support linear referencing. Among the contents will be the definitions of linear segments, linearly located features and events, and the definition of a linear reference system as such.

1.5 Addressing as an integral part of a spatial data infrastructure

Spatial Data Infrastructure (SDI) refers to the technologies, standards, arrangements and policies that are required to collate spatial data from various local databases, and to make these collated databases accessible and usable to as wide an audience as possible (Jacoby et al. 2002). There are forests of national and international standards, each necessarily limited in scope. An SDI provides a framework for the effective use of standards.

In the preparatory work of the European program for an SDI, INSPIRE (INfrastructure for SPatial InformationN in Europe), the concept of "reference data" has been defined as a category of datasets, that plays a special role in the infrastructure. According to the INSPIRE definition (EUROSTAT, 2002), reference data must fulfill the following three functional requirements:

- Provide an unambiguous location for a user's information;
- Enable the merging of data from various sources; and

- Provide a context to allow others to better understand the information that is being presented.

It is obvious that addresses fulfill all three requirements: in numerous legacy and modern IT systems, address information is recorded with the purpose of having an unambiguous identification of the real property, customer, citizen, business or utility entity in question. Secondly, addresses are used as one of the most important mechanisms to merge or link information from different sources together, e.g. when a bank uses the customer's address to look up information on real property or insurance.

Last but not least, addresses are used every day by citizens, businesses and government as a human understandable description of the location of a specific piece of information; for example, the address label on letters or goods for delivery is meant to give every actor in the delivery process a clear understanding of the desired final destination.

As a result of these considerations, addresses have been included explicitly in the final INSPIRE Directive in “Annex 1”, which contains the priority spatial reference datasets. A number of implementing rules are being developed to ensure that these data sets are interoperable and seamlessly accessible across all of Europe (European Parliament, 2007).

Due to their service, infrastructure and land administration responsibilities, it is commonly found that a local authority establishes and maintains address reference data for its area of jurisdiction. Where addresses are managed locally, address standards (unlike some other kinds of standards), tend to develop locally. The need for exchange between localities gives rise to the need for national standards, and then international standards. Similarly, the need for address reference data for areas that extend across these jurisdictional boundaries, thus requiring integrated address reference data nationally or internationally also prompts the development of national standards, and then international standards. Therefore the best evidence of the need for an international standard is all the work that has gone into developing national and local standards.

However, addressing is not always done locally. For example, almost all of the rural addressing in South Africa has been done nationally by the South African Post Office, Statistics South Africa, national departments, national utilities and private companies. The standard is also needed to help with providing addresses to those who do not have them yet.

A European survey on addresses and address data (EUROGI 2005) gives clear evidence that although address systems exist in European countries, with a long history as well, and although address master files or address registers are available in most countries on certain conditions, only very few published standards for address data exist, making the task of "interoperable and seamlessly accessible" address data sets "across all of Europe" even more difficult.

The INSPIRE directive and the development of a non-postal international address standard by OASIS, for example, provide evidence that there is an international requirement for interoperability and seamless integration of address data which can be realized by an international standard (or perhaps a suite of standards) for *all* kinds of addresses. The proposed “Workshop on an international address standard” that is planned for Copenhagen, Denmark in May 2008, and will be organized under the auspices of ISO/TC211's Working Group 7, Information communities, further illustrates that there is an interest in the standards community in the development of an international address standard.

1.6 Objectives of this paper

In this paper we explore the potential benefits of bringing the above-mentioned address standardization initiatives together to develop one, common international address standard (or a suite of standards); and we also explore the potential ways in which such a common international address standard could be developed. The objectives with this paper are:

1. to describe the benefits that could be realized by an international address standard;
2. to present some commonalities and differences between existing address standards; and
3. to explore different options for proceeding with the development of an international address standard.

2. BENEFITS OF AN INTERNATIONAL ADDRESS STANDARD

We describe the potential benefits of an international address standard by first investigating the benefits of international standardization, and then looking at the benefits of address standardization in particular countries and how these benefits can be internationalized.

2.1 Benefits of international standardization

A recent report by the ISO/TC211 Ad Hoc Group On Outreach Funding (Greenway, 2007), summarizes the benefits of standardization as documented in various studies (Delphi Group, 2003; DIN, 1999; DTI, 2005; NASA, 2005; Swann, 2000) that have attempted to quantify and qualify the economic benefits of standardization. Amongst the findings from these studies are:

- The benefit to the German economy from standardization amounts to more than US$ 15 billion per year (DIN, 1999);
- Standards contribute more to economic growth than patents and licenses (DIN, 1999);
- Standardization is a key part of the microeconomic infrastructure; it can enable innovation and act as a barrier to undesirable outcomes (Swann, 2000);
- Software standards create liquidity – the ability to leverage IT investment in unforeseen ways (Delphi Group, 2003);
- Detailed research work by a team of experts found that standards were associated with 13% of the recorded growth of UK productivity in the period 1948-2002 (DTI, 2005);
- Standards lower transaction costs for sharing geospatial data when semantic agreement can be reached between the parties (NASA, 2005); and
- Standards lower transaction costs for sharing geospatial information when interfaces are standardized and can facilitate machine-to-machine exchange (NASA, 2005).

The studies also point out some pitfalls of the standardization process, which should be taken into consideration in the development of an international address standard:

- It is clear that traditional public standards setting procedures are under pressure. It is widely perceived that they are not 'fast enough' (Swann, 2000);
- Uneven representation in the standardization process can lead to short-sighted standards (Swann, 2000);
- There is doubt that a producer led standardization process can give full account to customer interests (Swann, 2000); and
- Standards sometimes fail to meet expectations – usually due to the long lead times for developing a complete schema or the daunting task of implementing complex specifications (NASA, 2005).

In general, the benefits of an international standard are realized thorough its dual nature of being both descriptive and prescriptive. It is descriptive because it reflects the common beliefs and processes of a large number of experts throughout the world, and if the area under standardization is mature, then the standard will likely also reflect common practice. An international standard is prescriptive because these common beliefs and processes are intended to be adopted by all others (Rehesaar, 1996). In being descriptive, an international address standard would thus capture common beliefs of a large number of address standardization experts and reflect the common practices of address standardization in a number of countries. In being prescriptive, an international address standard would indicate what forms of address are preferred (e.g. because of their utility, ease of encoding or authority), and what forms are deprecated or should be retired (e.g. because of their ambiguity or instability). Care must be taken over trying to develop prescriptive standard prematurely.

These prescriptive forms and common beliefs and practices could guide countries when embarking on the process of address standardization for the first time. An international address standard would also allow the development of re-usable address-related software tools benefiting organizations and countries with fewer financial resources. A common data model to describe addressing systems along with address encoding formats enables address data transfer and exchange, and widens the audience for address-related web services so that the benefits associated with web services and data grids can be realized (Coetzee and Bishop, 2007). The standards provide the framework for building an address reference database but do not provide the content for the database.

2.2 Benefits of address standardization

Recent presentations at the Urban and Regional Systems Association (URISA) annual conference describe the value of standardized addresses to the economy, society and governance in the individual countries of Denmark (Lind, 2007), South Africa (Coetzee and Cooper, 2007a) and the United Kingdom (Barr, 2007; Nicholson, 2007). A summary of these benefits, together with benefits realized in other countries, is presented below. We also describe how these benefits of address standardization can be internationalized.

2.2.1 Economic benefits of address standardization

Addresses are a key part of any customer database, allowing companies to send invoices, ordered goods and promotional material to their customers, and if necessary, direct debt collectors. These addresses are obtained in different ways (e.g. paper forms or entered online) and often include errors and ambiguities that could be eliminated by capturing addresses in a standardized form. Such address databases are the data sources for the other uses of addresses that benefit the economy, particularly when they have been geocoded. Spatial analysis of geocoded customer addresses for the purpose of retail outlet planning can show where customers shop (obtained from their credit cards usage, etc.) relative to where they live. This can reveal gaps in the retail outlet network, outlet inventories that do not match the buying habits of the catchments for the outlet (e.g. because the people living there shop elsewhere), growth opportunities, etc.

In today's global market, big corporate organizations have to maintain customer databases with addresses from more than one country, and perform retail outlet planning across national boundaries. Address standardization enables address data interoperability which in turns makes the exchange of address data possible and facilitates the collation of address data into larger databases such as a provincial, national or international address database (Coetzee and Cooper, 2007b).

A functional addressing system based on an address standard can also generate downstream economic activities, such as producing and maintaining street maps and guides that are up to date, and facilitating and encouraging local tourism, so that the destinations can actually be found in a maze of streets (CODI-Geo/DISD, 2005).

Lind (2007) performed a cost-benefit analysis on the presence of ambiguous street names in Denmark and their impact on service delivery, illustrating in hard currency the economic benefit of having an unambiguous addressing system. The focus of the analysis was the 0,7% of all Danish street names which unfortunately have the property, that their name occurs more than once within a postcode area, thus requiring an extra address element (sub-location or place name) to be added to the address label in order to obtain uniqueness. The analysis showed significant annual costs for society, e.g. in the extra workload in mail delivery, ambulances being dispatched to the wrong address, uncertainty in data management etc, and concluded that the benefit of solving the problem and obtaining a standard address standard format which gives 100% unambiguous addresses, will easily outweigh the costs.

Within Great Britain most immediately citizen-facing services are delivered via local government and most require the identification of the point of service delivery. To cater for this there may be 30 to 70 different departments within a local authority all independently creating and maintaining address based datasets for specific service delivery. Enforcing a common address standard has facilitated new and faster inter-departmental communication with a consequent impact on the speed and quality of service provision as well as the development of new services. The simultaneous creation of local centralized address hubs has resulted in cost savings across all departments with examples of increased revenue from correctly enforced local taxation. The realization of the benefits of reducing the level of duplicated address maintenance and the redeployment of staff to more customer facing duties has taken longer but is underway.

A recent independent study by the Centre for Economics and Business Research (CEBR, 2006) concluded that a minimum benefit of £54.4 million per annum could be released by local government alone. This analysis was limited to those parts of local government directly involved with gazetteer creation and maintenance and excluded address users such as the emergency services. Case studies detailing specific local authority experiences can be downloaded from www.nlpg.org.uk and include for example:

- In one local authority area, the more disciplined approach to address management has resulted in £250,000 of additional property tax being identified and collected;
- In another local authority more integrated address data enabled some £40,000 of savings by improving the routing of refuse collection.

Given that regional and national government in the UK has grown from the same roots as local government and basically comprises a similar collection of operational areas albeit of increasing size, complexity and cost but with the same increasing interdependencies, the scaling of the local standard based solution to a national level with the corresponding would seem to suggest obvious benefits.

2.2.2 Social benefits of address standardization

Without an address standard, utilities within a country implement different addressing systems limiting the usefulness of addresses. In South Africa, for example, the social benefits of having a standardized address are illustrated by the perceptions of black citizens of South Africa who used to be “second class” citizens in the apartheid era. A delegate to one of the project meetings for the development of the South African address standard (SANS 1883) related his childhood story: he grew up in a rural area where they lived in a house without an address. His cousin lived in the city in a house with a proper address with a street name and number. He always had the notion that his cousin had a better life – just because he lived in a house with an address!

South Africa’s Financial Intelligence Center Act (2001) also requires a customer to provide proof of residential address before opening an account with a financial institution or before applying for credit. Thus, people living in rural areas cannot apply for the much needed credit to uplift them economically, unless they have an address. As part of the process of providing postal addresses for all the dwellings in a rural village (Coetzee and Cooper, 2007a), the South African Post Office sends a “welcoming pack” through the mail (to prove the address) and encourages local retailers to send promotional material to those at these new addresses. While many of us might consider this to be junk mail, for the people in these villages it shows that they are now part of the normal processes of modern society. Address standardization plays an important role in developing countries to make the rural population part of modern society and to assist them in uplifting themselves economically.

In fact, Farvacque-Vitkovic et. al. (2005) regard street addressing as the foundation on which civic identity can develop, and a prerequisite for the development of civic institutions. However, in this paper we follow a broader approach to addressing and we consider all forms of addressing, not only addressing based on streets, as a fundamental requirement for the development of civic identity. Some services are not delivered to street frontages (eg: telecommunications from poles running along the boundaries at the back of properties), and many do not have street frontage for their dwellings, particularly in informal settlements and in hostels. A citizen is not an anonymous entity lost in the urban jungle and known only by their relatives and co-workers; they have an established civic identity, enabling them to communicate with fellow citizens outside the traditional networks. In cities of developing countries, particularly in sub-Saharan Africa, urbanization often takes place informally, and cities are then challenged with urban management and the provision of services without a proper addressing system. For these countries, an international address standard with implementation guidelines will assist in the implementation of addressing systems and the associated maintenance of address reference data.

The descriptive nature of an international standard which reflects the common beliefs and processes of a large number of experts and also reflects world-wide common practice can assist developing countries in fast-tracking the implementation of address standardization and thereby realizing the benefits of address standardization.

The benefits of an address standard can be consistent across national boundaries. An international standard would provide (as national standards do now within their respective countries) a statement of best practices for address data management and in so doing, it would support more efficient data collection, maintenance, and detection and correction of address data errors. This would simplify the transfer of address data between agencies, projects, and applications. For example,

1. **Disaster management:** Collecting field reports of damage sites, receiving distress reports from home owners, producing maps for clean-up crews, identifying to be alerted in advance, etc. All these locations are specified by addresses that need to conform to a standard to save time and prevent mistakes.
2. **Urban planning**: Zoning, construction planning, approval, safety codes, reviews, inspections, citations, and appeals all need addresses which can be assigned and maintained by guidance from a standard.

2.2.3 Governance benefits of address standardization

In South Africa the value of standardized addresses to governance is illustrated in quite a few ways. First of all, the Independent Electoral Commission (IEC) makes extensive use of addresses in preparing for any election in South Africa. For example, addresses are used to ensure that voting stations are within reach of voters, and to analyze voting patterns after elections (i.e. where citizens voted relative to their address, not for whom they voted). Similarly, Statistics South Africa, which is responsible for the Census, uses address data to ensure that the Census reaches all citizens and prepares address maps to assist their agents in locating all citizens. During the Census, the address data is used to monitor the progress of the Census. Naturally, the IEC and Statistics South Africa exchange data to cross-reference voting and population, and for this a common base of standardized address reference data is required.

South Africa has three levels of government: local, provincial and national. The exchange of service delivery data referenced to common addresses assists in coordinating the planning and maintenance of service delivery across the three levels of government. Similarly, Nicholson (2007) reports that the National Land and Property Gazetteer (NLPG) in the UK is used to audit other national datasets, thereby supporting governance by ensuring better quality datasets.

In Denmark a business case report (National Survey and Cadastre, 2005) analyzed the potential benefits of making the standard address identifiers (postcodes, street names, address numbers and coordinates etc.) accessible by means of a set of web services which any IT developer could implement in web applications or portals free of charge. The analysis concluded that the proposed web services would improve the eGov infrastructure by making standardized address data easy available for all sectors at a low cost and by reducing uncertainty and errors caused by wrong or imprecise address data. Within the first three years, it was estimated that the benefits would outnumber the costs by a factor of 12:1.

In summary, the collection, storage, and management of address data are part of the everyday activities in both the private and the public sector. Today, digital address data are a necessity throughout an address data management life-cycle, from system planning through application design, operations, and maintenance. Automating, sharing, and leveraging address data through a widely-accepted standard provides a continuum of benefits:

It makes the sharing of address data easier, for example, address data compiled for one project or discipline is compatible with and readily available to other projects and disciplines.

- Sharing address data can improve the quality of the data by increasing the number of individuals who find and correct errors.
- Address data can be exchanged electronically.
- Address data can be collated and aggregated in a single cycle management phase, making it readily usable for subsequent phases.
- Duplication of efforts can be reduced, lowering production costs.
- Applications can be developed faster by working with existing standards-compliant address data.
- Conflicting address data are more easily resolved if it is standards-compliant.

3. EXISTING ADDRESS STANDARDS

In Section 3.1 and 3.2 we provide tables with information about existing national and international address standards, respectively. Section 3.3 follows with an overview table of the standards, and a discussion of these standards.

3.1 National standards

The five tables below provide general information about national address standards for Australia and New Zealand, Denmark, South Africa, the United Kingdom and the United States. Although other national address standards exist, we chose these standards because they are representative of national address standards in the developed as well as the developing world.

Table 1: Australia and New Zealand

Country	Australia
Standards Authority	Standards Australia and Standards New Zealand
Technical Committee	Technical Committee IT-004, Geographical information/Geomatics
Number	AS/NZS 4819:2003 (incorporating Amendment No. 1, published in 2006)
Name	Geographic Information – Rural and urban addressing
Structure	Two documents:

	1. The standard (Australia and New Zealand) 2. Amendment No. 1 applies to Appendix H – Guidelines for use in Assigning Addresses (Australia Only)
Status	Published as a standard for Australia and New Zealand
First started	1999
Published	2003 2006 Amendment No. 1
Distribution	SAI Global Ltd, GPO Box 5420, Sydney, NSW 2001 Standards New Zealand, Private Bag 2439, Wellington, 6020
Purpose	To provide users with a comprehensive guide that will encompass all aspects of rural and urban addressing.
Address definition	the conventional means of describing, labeling or identifying an address site; and an address site is an object, place or property.
Supporting material	The Geocoded National Address File for Australia (G-NAF) was the first implementation of AS/NZ 4819. The website http://www.psma.com.au/g-naf has information about the implemented data model. Other electronic material such as the presentation found at http://www.icsm.gov.au/icsm/street/presentation/presentation.swf

Table 2: Denmark

Country	Denmark
Standards Authority	XML-committee (Joint e-Gov data standards committee)
Technical Committee	OIOXML Core Component Working Group
Number	(none)
Name	OIOXML Adresseguide (en: Address Guideline) OIOXML Dokumentationsguide for Adressepunkt (en: Guideline for Address Point)
Structure	Two online documents
Status	Published as public data standards for eGovernment (not formal DS-standards by Danish standards body, "Dansk Standard"
First started	2003
Published	2006, 2007
Distribution	Online: http://www.oio.dk/files/Dokumentationsguide_for_adresse.pdf http://rep.oio.dk/bbr.dk/xml/schemas/2006/09/30/OIOXML%20dokumentationsguide%20for%20AdressePunkt.pdf
Purpose	To describe the address data elements and complex types including spatial properties in order to enable data exchange.
Address definition	(informal definition only:) a structured, textual description assigned as a common reference to a definite way of access to a building, a construction or developed or undeveloped plot of land.
Supporting material	The data standards are enforced by the "Law of Building and Dwelling Registration" and the "Statutory Order on Road Names and Addresses" which regulates the authority, guidelines and process of addressing and of address data management

Table 3: South Africa

Country	South Africa
Standards Authority	South African Bureau of Standards (SABS)
Technical Committee	SC71E – Geographic Information, the local mirror committee of ISO/TC211 – Geographic Information/Geomatics
Number	SANS 1883
Name	Geographic Information - Address standard
Structure	SANS 1883-1: Data format of addresses SANS 1883-2: Guidelines for addresses in databases, data transfer, exchange and interoperability SANS 1883-3: Guidelines for address allocation and updates
Status	Committee draft
First started	2006
Published	Not yet
Distribution	SABS, Private Bag X191, Pretoria, 0001, South Africa. Tel.+27 (0)12 428-6883, Fax. +27 (0)12 428-6928, www.sabs.co.za
Purpose	To describe the data elements of different address types in order to enable address data exchange.
Address definition	an unambiguous specification of a point of service delivery
Supporting material	Parts 2 and 3 provide guidelines respectively for address data in databases and the assignment of addresses. A website with overview information, sample data and presentations is available at www.cs.up.ac.za/~scoetzee/sans1883. The website is also available on CD-ROM.

Table 4: United Kingdom

Country	United Kingdom
Standards Authority	British Standards Institution
Technical Committee	IST/36
Number	BS7666:2006
Name	Spatial datasets for geographical referencing
Structure	BS7666-0:2006 Part 0: General model for gazetteers and spatial referencing BS7666-1:2006 Part 1: Specification for a street gazetteer BS7666-2:2006 Part 2: Specification for a land and property gazetteer BS7666-2:2006 Part 5: Specification for a delivery point gazetteer
Status	Adopted by local government in England, Wales and Scotland as basis for national gazetteers
First started	1995
Published	1995, 2000 and 2006
Distribution	Copies of the standard can be ordered from BSI customer services or from www.bsi-global.com
Purpose	To provide a common structure for gazetteers of any class of geographic object
Address definition	means of referencing an object for the purposes of unique identification and location
Supporting material	Conventions and guidelines produced by local government and available from www.nlpg.org.uk

Table 5: United States

Country	United States
Standards Authority	U.S Federal Geographic Data Committee
Technical Committee	Address Standard Working Group (working under sponsorship of the U.S. Federal Geographic Data Committee)
Number	Not yet assigned
Name	Draft Street Address Data Standard
Structure	Part 0: Introduction; Part 1: Address Data Content; Part 2: Address Data Classification; Part 3: Address Data Quality;\ Part 4: Address Data Exchange
Status	In preparation
First started	1996
Published	No
Distribution	to be determined
Purpose	The Street Address Data Standard provides, in four separate parts, data content, classification, quality, and exchange standards for street, landmark, and postal addresses: Data Content provides semantic definitions of a set of objects. This part specifies and defines the data elements that may appear in or describe street, landmark, and postal addresses. Data Classification provides groups or categories of data that serve an application. Classification data are the attributes common to elements of a group. This part defines classes of addresses according to their syntax, that is, their data elements and the order in which the elements are arranged. Data Quality describes how to express the applicability or essence of a data set or data element and include data quality, assessment, accuracy, and reporting or documentation standards. Data Exchange describes how to produce or consume packages of data, independent of technology and applications that will facilitate moving data between agencies and systems.
Address definition	an address specifies a location by reference to a thoroughfare, or a landmark; or it specifies a point of postal delivery.
Supporting material	None yet. An implementation guide is envisioned after the standard is drafted.

3.2 International standards

The five tables below provide general information about current international address standards developed by the International Organization for Standardization (ISO), the Organization for the Advancement of Structured Information Standards (OASIS), and the Universal Postal Union respectively.

Table 6: International Organization for Standardization (ISO) – ISO 11180

Standards Generating Body	International Organization for Standardization (ISO)
Technical Committee	ISO/TC 154, Documents and data elements in administration, commerce and industry
Number	ISO 11180
Name	Postal addressing
Structure	Single document, 12 pages
Status	Published in 1993, withdrawn in 2003
First started	Unknown
Published	1993
Distribution	ISO, Case postale 56, CH-1211 Geneva 20, Switzerland Telephone +41 22 749 0111. Facsimile +41 22 733 3430. http://www.iso.org/
Purpose	To specify the maximum size, presentation and structure of a postal address on forms complying with IS0 8439, Forms design – Basic layout.
Address definition	Does not define 'address'. Defines 'postal address' as: Set of precise and complete information on the basis of which an item can be forwarded and delivered to the addressee without searching and without there being any doubt.
Supporting material	None found

Table 7: International Organization for Standardization (ISO) – ISO 19112

Standards Generating Body	International Organization for Standardization (ISO)
Technical Committee	ISO/TC 211, Geographic information/Geomatics
Number	ISO 19112
Name	Geographic information — Spatial referencing by geographic identifiers
Structure	Single document, 20 pages
Status	Published as an International Standard
First started	1995
Published	2003
Distribution	ISO, Case postale 56, CH-1211 Geneva 20, Switzerland Telephone +41 22 749 0111. Facsimile +41 22 733 3430. http://www.iso.org/
Purpose	To specify ways to define and describe systems of spatial referencing using geographic identifiers rather than co-ordinates, as well as the components of a spatial reference system and of a gazetteer.
Address definition	Does not define 'address'. This standard covers the definition and recording of a spatial reference in the form of a geographic identifier based on a relationship with a location defined by a geographic feature or features.
Supporting material	A fact sheet for the standard, as well as the UML model for all the ISO 19100 series of standards, are available at http://www.isotc211.org

Table 8: International Organization for Standardization (ISO) – ISO 19133

Standards Generating Body	International Organization for Standardization (ISO)
Technical Committee	ISO/TC 2111, Geographic information/Geomatics
Number	ISO 19133
Name	Geographic information - Location based services - Tracking and navigation
Structure	Single document
Status	Published as an International Standard
First started	2001
Published	2005
Distribution	ISO, Case postale 56, CH-1211 Geneva 20, Switzerland Telephone +41 22 749 0111. Facsimile +41 22 733 3430. http://www.iso.org/
Purpose	To describe the data types, and operations associated to those types, for the implementation of tracking and navigation services. The standard includes an address model.
Address definition	Does not define 'address'. The address model describes a tentative model for a beginning set of address elements, generic addresses consisting of aggregations of those elements (applicable to contributing member countries). Examples of these elements are a street, street intersection, addressee, named place, postal code, and phone number.
Supporting material	A fact sheet for the standard, as well as the UML model for all the ISO 19100 series of standards, are available at http://www.isotc211.org

Table 9: Organization for the Advancement of Structured Information Standards (OASIS)

Standards Generating Body	Organization for the Advancement of Structured Information Standards (OASIS)
Technical Committee	Customer Information Quality
Number	n/a
Name	Name (xNL), Address (xAL), Name and Address (xNAL) and Party (xPIL)
Structure	Single document
Status	Committee DRAFT Specifications published for public review
First started	2000
Published	September 2007
Distribution	The standard and supporting material are available online at http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=ciq#download
Purpose	To deliver a set of XML specifications for defining, representing, interoperating and managing "PARTY (Person or Organization) INFORMATION" that are truly open, vendor neutral, industry and application independent, and importantly "Global" (ability to represent international data formats such as different types of party names and addresses used in different countries).
Address definition	a physical location or a mail delivery point.
Supporting material	Supporting documentation includes Frequently Asked Questions (FAQ), a General Introduction and Overview to the standard, a Package Overview, and a Technical Overview. XML schemas with supporting documentation are also available.

Table 10: Universal Postal Union (UPU)

Standards Generating Body	Universal Postal Union (UPU)
Technical Committee	POST*Code Project Team
Number	UPU S42
Name	International postal address components and templates
Structure	Part A: Conceptual hierarchy and template languages Part B: Element mapping conventions, template design considerations, address templates and rendition instructions
Status	1
First started	Before 2002
Published	2006
Distribution	Universal Postal Union – International Programme, Standards Programme, 3000 Berne 15, Switzerland. Tel: +42 31 350 3111, Fax: +42 31 350 3110, e-mail: standards@upu.net
Purpose	To provide a dictionary of the possible components of postal addresses together with examples of and constraints on their use.
Address definition	Set of information which, for a postal item, allows the unambiguous determination of an actual or potential delivery point, usually combined with the specification of an addressee and/or a mailee.
Supporting material	None found

3.3 Discussion on these standards

Table 11 below provides a summary overview of some of the features of the national and international address standards presented in the previous two sections.

Table 11: Overview of issues addressed in the address standards

	AS/NZ	DK	SA	UK	US	ISO 11180	ISO 19112	ISO 19133	OASIS	UPU
Geo-referencing with coordinates	Yes	Yes	Yes	Yes	Yes	No	Yes[3]	Yes	Yes	No
Postal addresses	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Non-postal addresses	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No
Data model	No[1]	Yes	Yes	Yes	Yes[4]	No	Yes	Yes	Yes	Yes
Data model format	n/a	UML	EBNF ERD UML	UML	XSD	n/a	UML	UML	XSD	Custom
Encoding formats	n/a	XML	CSV XML	CSV XML	XML	No	Yes[3]	Yes[3]	XML	XML
Metadata	Yes	No	Yes	Yes	Yes	No	Yes[3]	Yes[3]	No	No
Data quality	No	No	No	Yes[2]	Yes	No	Yes[3]	Yes[3]	No	No

[1]The standard does not include a data model but the Intergovernmental Committee on Surveying & Mapping (ICSM) have developed a Harmonized Data Model that includes a Street Address and is available at https://www.seegrid.csiro.au/subversion/xmml/ANZLIC_ICSM/HarmonisedDataModel/trunk/Documentation/index.htm

[2]These are provided through conventions and guidelines produced by local government organizations

[3]These are provided through other standards in the ISO 19100 series of standards, e.g. ISO 19115:2003 Geographic information - Metadata, ISO 19118:2005 Geographic Information – Encoding.

[4]There is no database model. The XML model provides for transfer of data, but is not a relational data model as required for address data.

From this table we can see that most of these address standards

- include geo-referencing by coordinates;
- describe *all* kinds of addresses (as opposed to only postal addresses);
- provide data models;
- use UML to describe their data models; and
- use XML as an encoding format.

Some of the standards include metadata and a few of the standards include data quality, though the trend is to specify data quality measures in a separate standard. What needs to be established is which features of an address standard support a geo-enabled address reference database (also known as a master address repository).

From the tables in the previous two sections, it can be seen that the definition of an address plays an important part in dictating the functionality of the related standards. Postal standards have the advantage of a known method of discovering and storing the address location: a local mail carrier and the postal hierarchy above them. However, this limits their applicability to other domains since a postal code is sometimes geographically removed from the physical location of the addressee. The national standards that include geo-referencing and address location provide a definition of an address that either states or implies that an address is a description for a particular place, in addition to being a set of text strings to be formatted for postal processing and other forms of service delivery.

Once the addresses themselves, their components and functionalities are in place, addresses pose a particular challenge in terms of content, such as textual and spatial information, and their meanings. These may include any number of assumptions dependent on geographic context. For example, SANS 1883 defines eleven types of addresses in South Africa, including *Farm Address* and *Informal Address*, which have data elements consisting of free text. Addresses in many countries are assigned with a bewildering variety of methods. Even an address as 'obvious' as *"615 20th Street"* might mean any of the following in the US, when trying to convert it automatically into a location – or perhaps something else.

- The 307th house on the right side on the 20th street in a series of parallel numbered streets beginning with 1st Street.
- A house with a front door 615 feet (198 meters) from the beginning of 20th Street, which runs along the southern edge of section 20 in the Public Land Survey System (PLSS).
- A house whose driveway is 15 address increments along 20th Street, which starts at the 600th address increment from the county courthouse, in a small town using the county address grid. There had been other numbered streets at one time, but all the others were renamed for prominent, deceased citizens over a period of years. The address increment could vary from 1 foot to 30 feet or more, so the distances implied by the address are impossible to guess without more information.

Each of the standards in the tables above went through an extensive discovery process to define address data, processes and scope, and these standards provide a glimpse of the variety of address types that an international standard will have to accommodate. The draft US standard, for example, expanded over time as communities with a variety of addressing methodologies each contributed to it. Some communities who participated in the standard creation process recognize zero (0) as a legitimate address number, some have negative address numbers, some use fractional addresses (5/9), while still others have many addresses without numbers at all. Communities with specific road naming strategies, those with road names in diverse languages, and those with orderly as well as chaotic road naming practices all contributed to the standard.

At this point in the US address standard development process, the draft standard represents all of the addresses in both form and content that the Address Standards Working Group (ASWG) was able to find in one large country. Similarly, the South African address standard includes all the address types currently used, with the possibility that some will become deprecated with time such as the *Site Address* (house number and place name, without a street name), while others such as the *Informal Address* (free format text description together with place name) will always exist to enable address data exchange but will never be used "formally" in an addressing system or as address reference data.

Our analysis of address standards includes countries in Europe (Denmark and the UK) and countries with strong European colonial influence (US, Australia and South Africa). It is to be expected that to a certain extent these countries face similar challenges regarding address standardization, especially since the thoroughfare or street plays an important role in most of these address standards. However, due to the rapid growth experienced in many cities of the developing world, street identification systems that existed in old neighborhoods and city centers have rarely extended to new ones (Farvacque-Vitkovic, 2005).

The *Site Address* and *SAPO-type village address* of the South African address standard provide for addresses that are not based on a street. For the *Site Address* the house numbers in a township (non-White settlements from the apartheid era) are assigned in sequence along a name-less street, while the numbers in a rural village of the *SAPO-type village address* are assigned (arbitrarily) in consultation with the local chief.

In some Asian countries, using South Korea as an example, a city is divided into neighborhoods (called *dong*) and urban sectors (called *gu*), forming a hierarchy, and the houses in a neighborhood are then numbered (Clodoveu, 2007). Thus an address does not necessarily include a street name and street number. Other South Korean addresses combine the street number and land lot number thereby causing confusion. Due to these causes for ambiguities, South Korea is currently revising its addressing system to include street names and street numbers (Lee, 2006).

In Japan, the hierarchy is city districts (called *ku*) divided into neighborhoods (called *chome*), which group together several houses to form a block. A house in a block is numbered in some sequence relative to the block not the street, either clockwise around the block or in older areas by construction date. Thus, it is difficult to locate a house based on its address (Farvacque-Vitkovic, 2005).

An international address standard should accommodate these addressing systems that are inherently different to the traditional thoroughfare- or street-based addressing systems. An international effort can make room for universal form and content, providing a way to communicate directly on a geographic level in a way that has not been previously possible.

4. A POTENTIAL INTERNATIONAL ADDRESS STANDARD

4.1 Different routes to an international address standard

International standards are developed through different routes, as *de facto* standards imposed because of the market domination of a product or company (e.g. Microsoft Word), through industry consortia (e.g. the Open Geospatial Consortium, Inc (OGC) and the Organization for the Advancement of Structured Information Standards (OASIS)), through inter-governmental agencies (e.g. within the United Nations system), or through open standards generating bodies (e.g. the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC)). Each route has benefits and limitations:

- ***De facto***: while these tend to be developed quickly, they tend to be parochial, lock-in old technology and be either narrowly focused or aggregations of special cases, rather than standardize the general model. They also can provide barriers to entry for other market players, either by incomplete disclosure or through patents.
- **Industry consortia:** nominally, these develop standards fairly quickly and openly, but they can be quite slow at times and are often dominated by the major funders in the consortia, particularly when there are fast-track processes for developing standards. Even their lowest fees are major barriers preventing participation by individuals and organizations from developing countries. However, they often make their standards available for free on the Internet.
- **Inter-governmental agencies:** while these carry the authority of government involvement, they tend to be very slow (particularly in setting up the standards development mechanism before the actual standards get developed) and do not involve industry or civil society.
- **Open standards generating bodies:** these have the broadest participation in terms of countries, regions, government, academia, industry and civil society, as they allow participation through liaison organizations as well as national bodies, though they do tend to be dominated to some extent by the better resourced countries. Generally, their standards have to be bought and many practitioners feel this is unacceptable, particularly if they helped to develop the standard. This need to sell their standards also applies to the national member bodies of ISO and their national standards. Much of the development of standards is done electronically, making it easier for those from developing countries to participate, even if they are unable to travel to meetings. However, standards developed by these open standards generating bodies are often perceived to be very slow, though this is invariably often not the case. In many cases, the delays in the standards being developed are caused by the rigorous review process they undergo, resulting in better standards. The International NGO Network on ISO (INNI), for example, was established to facilitate participation by environmental non-governmental organizations (NGOs) and other stakeholders in ISO, particularly in the development of standards related to environmental and social policy.

According to the NASA report on geospatial standardization (NASA, 2005), standards that proceed incrementally have a much better chance of adoption; and successful standards development and adoption rests on the ability of three key groups – government, industry, and the standards development community – to come together for a common good. These findings from the NASA report should be taken into consideration in the development of an international address standard.

In the report of the British Department of Trade and Industry (DTI, 2005), research confirmed the importance of standards being relevant and timely, so as to support the diffusion of technology rather than to hamper it (either by being developed before the technology is sufficiently mature to enable standardization, or by being developed too late and therefore locking users into legacy systems). We thus have to ask ourselves whether the time is right for an international address standard.

Blanchard (2001) lists four questions that developers of software standards should ask themselves before embarking on the standardization process and these questions apply equally well to other standards:

- Can a standard be reasonably implemented or accepted by the industry, i.e. is it worth the effort?
- Can a standard be developed which is specific enough to be useful to developers of products and services?
- Can there be a demonstrable benefit to at least some user populations for specific standardization efforts?
- Should we be aggressive and standardize when a technology is new or wait until it is "mature"?

There are several different options for developing an international address standard:

- Dovetail onto ISO 19112:2003, *Geographic information – Spatial referencing by geographic identifiers*, as was done in the UK with BS 7666.
- Revise ISO 19133:2005, *Geographic information – Location-based services – Tracking and navigation*, which by its own admission has a tentative address model, or add an address standard as a second part to the standard.
- Rework ISO 11180:1993, *Postal addressing*, which was withdrawn in 2003.
- Develop a new ISO standard from scratch.
- Develop the standard outside of ISO.

Developing the standard within ISO will allow the broadest participation from governments, academia, industry, NGOs, civil society and international organizations such as UPU and OASIS. However, this poses some risks since copies of the standards must be bought, and it is doubtful that most public agencies assigning or working with addresses will be able to do so. Two possible strategies to pursue are:

- Develop the international standard as an overarching abstract standard, from which national profiles can be developed, much like the North American Profile of ISO 19115. While the developers of the profiles will have to buy the ISO standard(s), the profiles can be freely distributed, which is important for a basic, grass-roots activity such as addressing.
- Develop the international standard as a joint project with an international

organization that makes their standards available for free to the general public, as is the case with standards developed jointly by ISO/TC 211 and OGC, for example.

The authors believe that the best approach now is to develop a new international address standard within ISO/TC 211, with participation from ISO/TC 154 (should they so choose) and other organizations, as addresses are a fundamental geospatial data theme. ISO/TC 211 has already developed several standards that are directly applicable to an international address standard (e.g. ISO 19112:2003, ISO 19133:2005 and ISO 19115:2005, *Geographic information – Metadata*), and it has the relevant expertise. The technical content of each the ISO 19100 standards has been encoded in the Unified Modeling Language (UML, ISO/IEC 19501:2005), and these UML models have been combined into one, massive UML model that ensures the ISO 19100 standards actually are harmonized with one another (this UML model is just of the technical content, it is not a database model).

The standard would conform to ISO 19112 *Geographic information – Spatial referencing by geographic identifiers*, but it might be confusing to make it part of ISO 19112. It would not be appropriate to rework ISO 11180 *Postal addressing*, as addresses are much more than just postal. The new standard would draw on ISO 19133 *Geographic information – Location-based services – Tracking and navigation*, but it would be confusing to make it part of ISO 19133 as addresses are used more widely than just for location-based services. The development of an extended address standard as part of the ISO 19100 series might require revision of the CI_Address data type in ISO 19115, *Geographic information – Metadata* and ISO 19139, *Geographic information – Metadata – XML schema implementation*. Harmonization with ISO 19151, *Geographic information – Dynamic Position Identification Scheme for Ubiquitous Space (u-Position),* which is currently in development, might also be required, as well as with the place identification specification that could be submitted to ISO/TC 211 to become a standard (Plews 2007).

4.2 Potential scope of an international address standard

As discussed above, before developing a standard one needs to know why it is being developed and for what it will be used. This tends to be captured in a scope statement for the standard, before the standard is written. With ISO standards, for example, it is not easy to change the scope. This is because the standard was approved based on its scope statement and changing the scope might make it unacceptable to some who voted for it.

The question then is what to include and what to exclude from the scope of an international address standard. As each country has its own unique socio-cultural addressing system which is implemented through legislation and the jurisdictional powers of its governing bodies, an international standard should not prescribe a universal addressing system to be implemented by all countries. It should cater for the multitude of character sets (by using ISO/IEC 10646:2003 – *Information technology -- Universal Multiple-Octet Coded Character Set (UCS)*) and different text ordering schemes of different countries (by implementing ISO14651:2007 – *Information technology – International string ordering and text comparison – Method for comparing character strings and description of the common template tailorable ordering)*. Rather:

- The standard should be an abstract standard, providing a framework for describing address systems across the world. A national or regional address standard could be produced as a profile (i.e. subset) to describe a very specific addressing system. An address (e.g. "1083 Pretorius Street, Hatfield, 0083") would be an instance of a particular profile.

- The standard should provide common terms and definitions of an address, address elements and related concepts.
- The standard should aim to make the address reference data from the multitude of addressing systems exchangeable.
- The standard should also provide a data model that enables the integration of address reference data from multiple source addressing systems.

Work toward an international address standard should begin with comparison and cataloguing of elements, attributes, syntax and semantics, from which an addressing ontology and common vocabulary of terms and definitions can be compiled. Looking at the commonalities that we identified amongst the existing national and international standards in Section 3, an international standard should include at least the following:

- vocabulary and ontology;
- geo-referencing by coordinates;
- *all* kinds of addresses (as opposed to only postal addresses); and
- an overarching data model (or reference model) to enable address data exchange.

A data quality standard typically specifies how conformance to a standard as well as data integrity should be tested. In order to develop a data quality standard, an addressing ontology, common vocabulary, and a data model have to be in place. Bearing in mind the findings from the NASA report (2005), an option is to start with a limited scope that can be expanded at a later stage when the standard is revised. For example, the first version of an international address standard could focus on a data model for address data exchange only, with further versions providing evolving data quality standards.

5. CONCLUSION

We started our paper with a discussion on addresses and associated standards; the current level of maturity in the understanding of addresses and address data; addressing in relation to reference systems; and address reference data as part of a spatial data infrastructure.

Benefits of address standardization have been realized in a number of countries and we related specific examples from these countries, and also described potential as well as realized economic, social and governance benefits of address standardization. Developing countries particularly can gain from international address standardization by leveraging standards-compliant technology from developed countries in the world, and by tapping into the common beliefs and best practices from a large number of experts around the world that are presented in a standard.

The commonalities and differences between existing address standards, both national and international, are represented in the tables of section 3. The features that are present in most of the standards are

- geo-referencing by coordinates;
- *all* kinds of addresses (as opposed to only postal addresses);
- a data model;
- UML to describe the data model; and
- XML as an encoding format.

We explored different options for proceeding with the development of an international address standard. The authors believe that the best approach is to develop a new international address standard within ISO/TC 211, as addresses are a fundamental geospatial data theme, and because developing the standard within ISO will allow the broadest participation from governments, academia, industry, NGOs, civil society and international organizations such as UPU and OASIS. Particularly, involvement by relevant organizations will be encouraged to get the broadest possible participation. However, developing the international address standard within ISO implies that copies of the standards must be bought, and we propose to either develop an abstract standard with regional profiles or to develop the standard jointly with an organization that makes their standards available for free. This will help ensure that the standard gets to the local authorities who ultimately have to implement the standard in their areas of jurisdiction.

While we think that it is still too early to start formulating a scope statement, our analysis of the benefits of international address standardization together with the analysis of existing standards, suggests that a first version of an international address standard should include at least the following:

- vocabulary and ontology;
- geo-referencing by coordinates;
- *all* kinds of addresses (as opposed to only postal addresses); and
- an overarching data model (or reference model) to enable address data exchange.

The intention of the "Workshop on an international address standard" (planned for Copenhagen, Denmark in May 2008) is to give direction to the future of an international address standard.

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