Developing a Comprehensive Address Data Standard for the United States

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Abstract

The "United States Street, Landmark, and Postal Address Data Standard" is a draft data standard for United States address information. The draft standard defines and specifies elements and structures for organizing address data, defines tests of address data quality, and facilitates address data exchange. The draft standard has four parts: Data Content, Data Classification, Data Quality, and Data Exchange.

The Address Standard as now drafted goes well beyond existing postal and assignment standards in the following respects:

1. It proposes a new definition for addresses: “An address specifies a location by reference to a thoroughfare or landmark; or it specifies a point of postal delivery.”
2. It defines the address elements and attributes needed for database records, data validation and documentation, and data exchange, as well as for creation of mailing lists.
3. It classifies addresses by their internal syntax, rather than their business purpose.
4. It provides a simple, complete taxonomy of US address patterns.
5. It introduces the idea of an address scheme (a set of local rules by which new addresses are assigned and old ones checked within a specific area).
6. It provides for an address identifier for each different address. (I disagree with this change. We do require an identifier.)
7. It provides for relating address locations to their corresponding coordinate and linear reference locations.
8. It provides attributes that comprise record level metadata about an address including identifiers, classification, feature type, accuracy, spatial referencing, lineage, and assignment authorities.
9. It incorporates a comprehensive set of data quality tests for address data, including SQL-based pseudocode.
10. It incorporates a comprehensive Extensible Markup Language (XML) data model to unambiguously exchange and transfer data.

The paper will describe the draft standard in detail, and will further discuss the process of development, which was broadly inclusive of address creation and maintenance agencies (primarily local governments), address aggregators, and state and federal bodies.

1. Introduction

U.S. Addressing Practices. Within the United States, no central authority governs addressing. Almost all addresses are and always have been created, assigned, and recorded by municipal or county governments. Within their jurisdictions local governments might not control addressing within military installations, university campuses, and large tracts of federal or state lands.

Addressing became widespread in U.S. cities in the late 19th century, when the Post Office made it a prerequisite for house-to-house mail delivery (USPS 2006b). Within the past 30 years, E-911 technology has stimulated the adoption of addressing systems in many areas where house-to-house mail delivery is not available, but there are still areas in the U.S. where no addresses have been assigned. From the beginning, addressing and address record-keeping have been a local prerogatives and duties. As a result there is substantial variation in practices among jurisdiction and, typically, between departments within the same jurisdiction.

U.S. federal agencies, chief among them the United States Postal Service (USPS) and the Census Bureau, have long been charged with compiling and maintaining nationwide address lists in the course of their duties, and with setting standards for doing so. However, federal agencies are address aggregators rather than address authorities. The lists they compile are not exhaustive (the USPS compiles only addresses where mail is received; the Census Bureau only those addresses needed to carry out complete census enumerations.) The scale and scope of their mandates gives federal agencies nationwide influence as exemplars of expert practice, but federal agencies have no power to compel states, local governments, private businesses, or citizens to use or conform to their standards. The federal government cannot dictate to local governments how to assign addresses, nor how to maintain their address information.

Over the past 150 years, street addresses have become the location identifiers most widely used by state and local government and the public. Street addresses are critical information for administrative, emergency response, research, marketing, mapping, GIS, routing and navigation, and many other purposes. Because they have evolved over many decades, under the control of thousands of local jurisdictions, in many different record and database formats, and to serve many purposes, different address formats and types pose a number of complex geoprocessing and modeling issues. As a consequence, government agencies struggle with these issues as they seek to integrate large, mission-critical files into master address repositories.

The Address Standard Working Group (ASWG). The FGDC was established in 1990 as an interagency committee to coordinate federal geospatial activities. In 1994 the FGDC was specifically directed to coordinate the federal government's development of the National Spatial Data Infrastructure (NSDI), and to develop standards for implementing the NSDI (FGDC 2004).

In the same year, the U.S. Congress enacted the Census Address List Improvement Act of 1994, which directed the Census Bureau to "publish standards defining the content and structure of address information which States and local units of general purpose government may submit to the Secretary to be used in developing a national address list" (U.S. Code Title 13 (Census), sec. 16(a)(1)). Work began in the context of FGDC's

NSDI framework standards development, in which the Census Bureau chaired the FGDC Subcommittee on Cultural and Demographic Data (SCDD). A draft standard was published for public review in 2001, revised, presented again in 2003, and once again withdrawn for revision.

These efforts led the Urban and Regional Information Systems Association (URISA) to propose, with the support of the National Emergency Number Association (NENA) and the U.S. Census Bureau, the convening of an Address Standard Working Group (ASWG) to build on previous work in developing a national Address Data Standard. The ASWG was to include representatives from a range of interested federal, state, regional, tribal, and local government agencies, the private sector, professional associations, and interested individuals. The proposal was accepted by the FGDC Standards Working Group on April 13, 2005. The ASWG has worked under the authority of the Census Bureau as chair of the FGDC SCDD.

The ASWG prepared a draft standard, which was widely circulated in August-September of 2005, followed by a second draft (based on over 150 comments received) that was posted for public comment in December 2005 and January 2006. Since then, the ASWG has developed the standard further, by responding to additional comments and conference discussions, and drafting additional material, integrating related standards, and preparing the final version for submittal to the FGDC. Upon submittal, the FGDC will consider the draft standard for formal public review and adoption.

2. Antecedents and Needs for a Comprehensive Address Standard

The ASWG's work builds on and incorporates two fundamental prior bodies of work: USPS postal addressing standards and the Census Bureau's GBF/DIME and TIGER files.

USPS Postal Addressing Standard. USPS postal addressing standards derive from USPS efforts dating back to the 1950's to automate and streamline mail sorting (USPS 2006b). As part of those efforts, the USPS has compiled a nationwide database of mailing addresses, and set forth specifications for standardizing mailing address (USPS 2006a). USPS postal address standards were developed to support:

1. Creation of a master address list, against which input addresses can be matched.
2. Rules for standardizing input addresses for matching against the master list.
3. Rules for formatting addresses (including abbreviations) so they fit on a mailpiece and can be readily interpreted by mail sorters.
4. Use of standard abbreviations for street types, directionals, and state names.
5. Use of a single general format for all addresses.
6. Rigorous definition of address syntax only to the level of mailing address "lines".

USPS Publication 28 (USPS 2006a) was first published at least twenty years ago and has been widely accepted and implemented with few changes since. It compresses into 43 pages an unrivalled wealth of experience and analysis of the facts of US address patterns. It has been a foundation for every US address standard since, including the Content and Classification parts of the ASWG's draft standard.

Because the USPS mandate is restricted to postal duties, the USPS postal addressing standards do not support several important requirements of address authorities and non-USPS users. Specifically:

1. The standard is intended solely for mailing addresses.
2. Address elements are named, and examples are given, but the elements are not formally defined..
3. No address classes or syntaxes are defined. One general record structure is provided (Delivery Line, Last Line) for all addresses.
4. As a result, USPS Publication 28 permits many different address record structures, and does not provide clear guidance on several points of address parsing and data exchange.
5. No specific data quality tests are provided within USPS Publication 28, except to note that valid addresses are those that can be matched against the USPS ZIP+4 and City State files.
6. There is no provision for mapping or assignment of geographic coordinates to addresses, because the USPS does not compile postal address maps.
7. There is no provision for address metadata or documentation.

Census GBF/DIME and TIGER Files. Addresses were brought into the GIS realm by the Census Bureau's efforts to automate geocoding for the 1970 census. Most importantly, in 1967 the Census Use Study Team applied the principles of map topology to develop the GBF/DIME file (later developed into the TIGER file) and associated address standardization and matching software (GIS History Project, 1997). The GBF/DIME file provided a way to encode the geometry of street networks and to relate street segments to tables of their address ranges. Extended nationwide, the GBF/DIME file provided the first basis for geocoding programs that automated the process of mapping addresses to specific x,y coordinate locations.

However, due to Census Bureau confidentiality requirements, the GBF/DIME and TIGER files provided ranges only, not individual addresses. The massive undertaking of nationwide topological road network sufficed for census enumeration, but it was frustratingly imprecise for local government needs, and there was no efficient way for the Census Bureau to incorporate and check corrections offered by local authorities.

The Need for a Comprehensive Address Data Standard. A comprehensive address standard must support postal delivery and census enumeration, as well as a broader range of operations: local government administration, intergovernmental cooperation, emergency dispatch, the creation and administration of master address repositories by local address authorities, and the aggregation of local records into larger regional, state, and national address databases.

Local governments must record and locate every address within and around their jurisdictions. Local governments require a located address for every address that appears anywhere in their administrative records--every residence, business, public structure, building permit, emergency response site, voter, school child, and public service client, including those addresses where no one resides and no mail is received. In many places addresses are also used to identify infrastructure facilities, including bus stops, fire hydrants, utility poles and meters, cell phone towers, manholes, and signs.

Additionally, local governments need unambiguous ways to exchange data among different units of government, both at the local level, e.g., city to city, or city to county, and between different levels of government, e.g., from city or county to regional, state and federal agencies. The need is critical in times of emergency.

Emergency responders require more than accurate address records. They must be able to get an emergency vehicle to the address, under circumstances when minutes matter. Under these circumstances, having well documented, standardized address data can mean the difference between life and death.

Emergency dispatchers have a particular concern about the relationship between addresses and coordinate values due to the high volume of cell phone calls, which report a caller's coordinate location, but no address. Translation from the coordinates to an address is of increasing importance for dispatchers and first responders.

To meet these needs, local address authorities must create master address repositories that replace the numerous isolated, incomplete departmental address data files with one authoritative, integrated geographic address database. The construction of master address repositories is of paramount importance at the local level, because it permits department to integrate address-related records, and ultimately operations, across department lines. The repository must include, not just the address itself, but its coordinate location, and documentation of where the address record originated and whether it is (or ever was) valid. To check validity and facilitate data maintenance, the repository must record the business rules by which addresses are assigned.

Finally, the repository should be constructed consistent with a common set of data elements, attributes, and structures used to exchange data and pass it on to address aggregators such as regional, state, and federal agencies (including, for example, the USPS and the Census Bureau).

To support these needs a comprehensive address standard must incorporate the foundational strengths of postal addressing standards and Census TIGER files, and in addition provide for:

1. Recording of all addresses.
2. Systematic definition of all the address elements and syntaxes that are required to compose address records and store them within relational databases and geographic information systems.
3. Systematic definition of all the attributes needed for address mapping, documentation, and quality testing, such that they can be related to specific addresses within relational databases and geographic information systems.
4. A unique address ID for each address.
5. Relating addresses to coordinates and linear reference locations.
6. Relating addresses to alias addresses.
7. Address metadata, including record-level metadata such as the status (future, active or retired) and period during which the address was/is in use.
8. Systematic address data quality testing, error-trapping, and anomaly identification.
9. Compilation of the local address assignment rules into an address schema as a basis for address assignment and quality testing.

10. Specification of exchange formats such as XML that enable electronic address data exchange between different institutions.
11. Reference to relevant standards to support integration of addresses into the U.S. NSDI and harmonization of the U.S standard with address standards of other countries.

The ASWG draft standard is intended to build on the strengths of the USPS and Census work by supporting address data creation, classification, mapping, documentation, quality control, and exchange.

3. The United States Street, Landmark, and Postal Address Data Standard

The "United States Street, Landmark, and Postal Address Data Standard" has been developed in conformance with the FGDC's "FGDC Standards Reference Model" (FGDC 1996). The model defines four types of standards, of which this is a data standard. It is comprised of four parts, developed as an integrated whole: data content, data classification, data quality, and data exchange. The standard is intended to be fully consistent with USPS Publication 28 (USPS 2006a), the Census Bureau's TIGER File data structure, the FGDC Content Standard for Digital Geospatial Metadata (FGDC 1998), and the FGDC's National Spatial Data Infrastructure (NSDI) Framework Data Content Standard (FGDC 2006b). Altogether the standard incorporates reference to about 30 other standards and specifications.

The standard is intended to serve the needs of those who create, administer, and exchange data from master geospatial address repositories. As such it differs in several fundamental respects from previous US address standards.

A New Address Definition. The standard proposes a new definition of "address":

"An address specifies a location by reference to a thoroughfare, or a landmark; or it specifies a point of postal delivery."

This definition differentiates addressing from the two other types of spatial referencing systems, coordinate reference systems and linear reference systems. The difference rests, not on what the systems locate, but on what they refer to in order to specify a location. Coordinate reference systems specify location by reference to a grid, spheroid, or geoid; linear reference systems specify location by reference to a route, beginning point, distance, and, optionally, offset distance.

The definition also gives the three broad groups of address classes: thoroughfare addresses, landmark addresses, and postal delivery point addresses.

A Syntactical Approach to Address Classification. The standard classifies addresses according to their syntax, that is, their address elements and the order in which the elements are arranged. Syntax determines the record structure needed to hold and exchange an address, and often it is all that is known about the addresses in a given file. Classifying addresses by syntax rather than semantics (i.e. meaning) allows the users of the standard to focus on record structures, and to avoid making any assumptions about address validity or what type of feature the address might identify.

A U.S. Address Taxonomy The standard classifies all US addresses into a simple, complete taxonomy of ten US address patterns. For each class, the standard provides the name, syntax, defining characteristics, examples, and notes; XML tag, model, and example; and quality measures and notes. The ten classes are:

- Thoroughfare Address Classes
    - Numbered Thoroughfare Address ("123 Main Street")
    - Intersection Address ("Fifth Avenue and Main Street")
    - Two-Number Address Range ("405-411 West Green Street")
    - Four-Number Address Range ("900-962, 901-963 Milton Street")
    - Unnumbered Thoroughfare Address ("Forest Service Road 698")
- Landmark Address Classes
    - Landmark Address ("Statue of Liberty")
    - Community Address ("123 Urbanizacion Los Olmos")
- Postal Delivery Address Classes
    - USPS Postal Delivery Box ("PO Box 16953")
    - USPS Postal Delivery Route ("RR 1, Box 100")
    - USPS General Delivery Office ("General Delivery")

In addition, a catch-all General Address Class is defined for files that hold addresses from various classes, and for addresses such as foreign addresses that might not fit in any of the thoroughfare, landmark, or postal delivery classes.

Address Elements. The standard names and defines the simple and complex data elements needed to construct addresses, and for each one provides, among other information, its name, definition, data type, existing standards (if any), domain of values (if any), examples, and explanatory notes; XML tag, model, example, and notes; and data quality measures and notes. The elements are too numerous to list here, but they cover:

- Address numbers and their components
- Street names and their components
- Occupancies (apartments, offices, suites, etc.) and their components
- Landmark names
- Larger areas (place names, states, ZIP Codes and Zip+4, and country names)
- USPS postal address elements (PO Boxes, rural routes, overseas military addresses, general delivery, etc.)
- USPS address lines (Delivery Line and Last Line, as specified in USPS Publication 28)

Address Attributes for Documentation, Mapping and Quality Control. The standard defines a number of attributes needed for address documentation, mapping, and quality control. For each attribute, the standard provides the same information that is provided for the address elements. The attributes are too numerous to list here completely, but key attributes include:

- A unique identifier for each different address, to serve as a primary key in an address database.
- The address authority that assigned the address, the dataset where it is found, and the dates the address was created and retired.

- Attributes to express the address location in terms of geographic coordinates and linear referencing.
- Lifecycle status (potential, proposed, active, retired).
- Class (in terms of the taxonomy described above).
- Feature type (the type of feature located by the address, e.g., parcel, building, entrance, occupancy, infrastructure component, etc.).
- Official status (official, alias, unofficial, etc.).
- Related address identifier (to relate, say, an alias address to its official address, or a landmark address to its equivalent thoroughfare address.
- Various attributes that describe specific elements, such as address number parity, address range type, and place name type.

Collectively the attributes constitute record-level metadata for each address. These attributes overlap somewhat with the file-level metadata specified in FGDC"s "Content Standard for Digital Geospatial Metadata" (FGDC 1998). Attributes that are the same for all records in a file can be provided in the file-level metadata. If they vary from record to record (e.g., in a file aggregated from multiple sources), they can be included in the record-level metadata.

Address Schema: The Local Framework for Address Assignment. The standard introduces the idea of an address schema--the framework of local rules, both spatial and non-spatial, by which new addresses are assigned and old ones checked within a specific area--and defines the elements needed to compose or describe a schema. The schema, in turn, is important to data quality testing.

Data Quality: A Complete Suite of Data Quality Tests. The standard provides a complete suite of data quality tests for all address elements, attributes, and classes. The tests are developed in terms consistent with the FGDC's "Content Standard for Digital Geospatial Metadata" (FGDC 1998) and corresponding ISO, OGC, and SDTS standards. Each test specification includes the scope, measure, and procedure of the test; an SQL pseudocode script; and parameters for calculating anomalies as a percentage of the data set.

Data Exchange: XML Schema Document (XSD) and XML. The standard includes an XSD that integrates the XML element, attribute, and class models into a single XML schema. The XSD provides the basis for complete XML data exchange templates for monolithic and transactional data exchanges.

A Data Model, but Not a Database Model. The XSD defines an address data model. It states how simple elements can be combined into complex elements, and how elements can used to compose addresses, and how attributes describe addresses and their elements.

However, the standard does not provide a database model with table structures or relationships. There is no Unified Modeling Language (UML) diagram or entity-attribute diagram. The standard does not prescribe one specific design for constructing complex elements from simple elements, or addresses from their complex and simple elements. It does not specify how to relate address numbers to street names, for example, or how to relate landmark addresses to their corresponding street addresses, or how to relate

current addresses to their retired predecessors, even though these and other tasks are crucial to the creation and maintenance of an address database.

Instead, the standard supports multiple levels of compliance, from the two-line format prescribed in USPS Publication 28 to a highly-parsed, fully-normalized database. The standard provides fully-described elements, attributes, and classes, but it accommodates a range of different design choices in composing, relating, and describing elements and addresses. These choices are left as implementation matters, to be decided locally in accordance with local resources, circumstances, rules, customs, and anomalies.

4. Standard Development Process

Because addresses are created by such decentralized processes, and because the standard must satisfy such a wide range of requirements, the ASWG has sought from the outset to make the development process as open and broad-based as possible. This has involved:

- Publicizing the effort via numerous channels, and involving representatives from various communities.
- Using wiki technologies and teleconferences in place of email and meetings.
- Posting drafts on the web and soliciting comments by webform.
- Focusing on practical needs and usefulness.

Broad Awareness and Participation. The ASWG has sought by various means to make the geospatial and addressing communities aware of the development of the standard and to involve as many as possible in the effort. The ASWG invited participation from and via professional associations representing geospatial professionals, local government officials, and emergency responders, including the National Association of Counties (NACO), GITA (Geospatial Information Technology Association), the American Association of Geographers (AAG), URISA, NSGIC (National States Geographic Information Council), and NENA (National Emergency Number Association). The draft standards, when posted, were widely announced in the geospatial and standards online media. ASWG members have made numerous presentations on the standard at conferences and meetings. In addition, the ASWG has regularly briefed various federal groups, especially the FGDC and Census, about progress on the standard.

Wiki Collaborative Website. To encourage wide participation, the ASWG set up an interactive "wiki" web-site using free and open-source software (TWiki, from http://twiki.org/). Wiki software posts a draft document (in this case, the working draft of the standard) on a server and enables anyone to edit or comment on it via internet. Comments and changes, once saved, are immediately visible to all. Anyone can add comments and ideas, or join in discussions (and sometimes arguments) over various aspects of the standard.

The ASWG wiki is open to anyone providing a name and a valid email to which to send a password. (The site is password protected only to keep out spam.) To date, over 200 individuals have signed up to view the site, provide comments, enter discussions and participate in the development of the standard. The wiki site has fostered discussion

among widely scattered individuals and improved the quality of discourse in several ways:

1. All conversations are public—everyone can see everyone else's comments. Private backchannel communications via personal email are outside the development effort.
2. All conversations are written. There is time to reflect and offer measured, thoughtful responses to the comments of others.
3. There is no need to reconcile multiple versions and sets of comments. No one is obliged to wonder who has the “best” version at any given moment. It is posted on the wiki site.
4. Meetings are minimized, and when they are needed, they can be held more easily by teleconference, with everyone having access to the current version.
5. Useful documents, once found, can be posted in a wiki library for all to use.
6. All of these factors have been useful in obtaining information and debating points of concept, practice, and actual address conditions that need to be reflected in the standard.
7. A number of commenters have provided the ASWG with important information about specific addressing systems, practices, or related standards, which has led to useful follow-up conversations.

Drafts for Public Comment via Webform. The ASWG posted a first draft on the standard two months after starting work, in the summer of 2005. It was posted on the URISA website, with copies available for download, and all comments were submitted via webform so that as many people as possible had access. Over 125 comments were received on this draft. A second draft was posted in December 2005, which received over 180 comments. The Committee has since made some significant revisions to incorporate these comments, and to respond to issues that they raised. This is an unprecedented level of review for a standard that has not been officially submitted as a draft to FGDC. Wide early review has greatly improved the quality of the draft that will be formally submitted to FGDC, and, we hope, increased interest in reviewing the final draft.

Focus on Practical Needs and Usefulness. The ASWG’s purpose is to create a standard that will be useful and used. To be useful and practical, the standard must be rooted in actual practice. Therefore the ASWG has sought advice and comment from practitioners: local government GIS managers, planners, assessors, emergency responders, school districts, election officials, software developers, data aggregators, postal officials and census geographers, to name a few. To be useful, the standard must reflect and build on the processes of address creation, management, and use. The standard must be developed by people who understand the local business work flows that utilize addresses in a real-time environment.

5. Conclusion

The FGDC, Census Bureau, and ASWG have sought, in carrying out this work, to draft a standard that supports the full range of address data needs and incorporates address data into the NSDI, thereby helping to make the U.S. spatial data infrastructure truly national.

The United States has many addresses derived from Spanish, French, and other languages, and all are accommodated by the standard. The ASWG believes that the principles and syntactical approach used here can also be applied in other cultures and countries. We expect that, if they are applied, address elements will be found to vary little from country to country, and that syntaxes will vary more. We would be interested to correspond with other groups seeking to apply this approach to the creation of a national address data standard.

Acknowledgments

The Address Standard Working Group (ASWG) is an initiative of the Urban and Regional Information Systems Association (URISA), working under the auspices of the U.S. Federal Geographic Data Committee and the U.S. Census Bureau, with support and cooperation from the National Emergency Number Association (NENA). The ASWG has been supported in part by a grant from the FGDC. The ASWG co-chairs gratefully acknowledge support and assistance from URISA, FGDC, Census, and NENA, and from the many persons who have commented on two earlier drafts of the standard.

This views expressed in this paper are those of the authors alone, and should not be attributed to the sponsoring and supporting agencies and organizations, nor to the authors' employers.

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