Standard on Digital Cadastral Maps and Parcel Identifiers

Approved January 2012

International Association of Assessing Officers

This standard revises and replaces the July 2003 *Standard on Digital Cadastral Maps and Parcel Identifiers*.

The assessment standards set forth herein represent a consensus in the assessing profession and have been adopted by the Executive Board of the International Association of Assessing Officers. The objective of these standards is to provide a systematic means by which concerned assessing officers can improve and standardize the operation of their offices. The standards presented here are advisory in nature and the use of, or compliance with, such standards is purely voluntary. If any portion of these standards is found to be in conflict with the *Uniform Standards of Professional Appraisal Practice* (*USPAP*) or state laws, *USPAP* and state laws shall govern.

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Standard on Digital Cadastral Maps and Parcel Identifiers

1. Scope

This standard provides recommendations on the development and maintenance of digital cadastral assessment maps, parcel data layers in a geographic information system, and parcel identifiers. It describes digital mapping system components, content, design, creation, maintenance, and contracts. It also discusses deed processing and parcel identification systems. This standard addresses computerized mapping systems; see the *Standard on Manual Cadastral Maps and Parcel Identifiers* (IAAO 2004) for information on manual parcel mapping. Technical aspects of the standard and technical recommendations may apply universally; however, many of the specific recommendations are more pertinent for local jurisdictions maintaining in house parcel-mapping systems. State mapping functions are not addressed in this standard, although many aspects of the standard may be applicable to state and provincial systems provided for local assessor use.

2. Introduction

The principal responsibility of the assessor is to locate, inventory, and appraise all property within the jurisdiction. A complete set of maps is necessary to perform this function. Maps help determine the location of property, indicate the size and shape of each parcel, and reveal geographic relationships that affect property value. Maps and map data are important not only for assessors, but also for other governmental agencies, the public, and the land information community (such as realtors, title companies, and surveyors). In addition, the assessor must track current ownership of all parcels, so that the proper party can receive assessment notices and tax bills. Computerization of map and parcel data can enhance the capability to manage, analyze, summarize, display, and disseminate geographically referenced information.

2.1 Computerized Mapping

Computerized mapping systems may be referred to by several names. They include:

- Geographic information system (GIS)
- Land information system (LIS)
- Digital multipurpose cadastre
- Multipurpose land information system (MPLIS)
- Land parcel database

For purposes of this standard and for consistency with other IAAO standards the term "digital cadastral mapping system" will be used.

2.2 The Value of Digital Cadastral Maps

Working with digital cadastral maps and tabular parcel-related data in a GIS, users can selectively retrieve and manipulate layers of parcel and spatial information to produce composite maps with only the data they need. Sharing GIS files over an internal or external data network makes parcel maps and related attribute information widely available, and reduces the duplication of effort inherent in separate map systems. Such sharing is becoming increasingly sophisticated, ranging from allowing users to download data or prepared maps, to allowing users to make sophisticated queries that may draw on the power of the host GIS's software and hardware.

2.3 Components of a Digital Cadastral Mapping System

A digital cadastral mapping system should have the following components:

- Reference to a geodetic control network
- Current base map layer (ideally, photogrammetrically derived)
- A cadastral layer delineating all real property parcels
- Vertical aerial photographs and/or images (ideally, orthorectified)
- A unique parcel identifier assigned to each parcel
- A means to tie spatial data to attribute data (ownership and parcel characteristic files)
- Additional layers of interest to the assessor, such as municipal boundaries, zoning, soil types, and flood plains

2.4 The Role of the Assessor

The assessor may assume many different roles in the management of a jurisdiction's digital mapping system or GIS. The assessor may have the lead role in mapping parcels and also street centerlines, crime scenes, zoning, and other layers for other offices. In contrast, the role may be limited to maintaining a parcel layer, leaving responsibility for other layers to the relevant offices (for example, crime scenes to the sheriff) or to a central office (a jurisdiction-wide GIS agency, or an information technology department). In any case, the assessor must retain the ultimate authority to inventory, create, and define parcels and parcel identifiers for property tax purposes.

3. Elements of a Digital Cadastral Mapping System

A mapping system for assessment purposes includes the maps, accompanying records, and resources to support mapping. In the digital environment it should be designed to work seamlessly as a key component within a GIS. The data format and map projection should be compatible with other GIS data layers in the jurisdiction, and it should be well documented, with metadata that explains how it was created and how it will be maintained. At its core, it should contain the following elements:

3.1 Geodetic Network

A geodetic control network consists of monumented points whose locations on the surface of the earth are defined with certainty. These points may be described in terms of latitude and longitude, but are more commonly used when projected to state plane coordinates. Additional points in the field are often collected in preparation for georeferencing vertical aerial photography and base maps. Density and placement of control points should be related to map scale, population density, property value, accuracy specifications, and anticipated product lifespan. Today, professional land surveyors are using global positioning systems (GPS) to locate such points with a very high level of accuracy.

In the future, improvements in GPS satellite signals, receiver equipment, satellite based augmentation systems (SBAS), and positioning techniques may reduce the need for dense on-the-ground control networks. A few precise control points tied to continuously operating reference stations (CORS)—especially those that broadcast their signals, may fulfill this function. Assessors should support efforts to create such stations and to mandate their use when preparing plats, surveys, and property boundary descriptions.

3.2 Base Map Layers

Base maps locate the major physical features of the landscape such as roads, water features, elevation contours, fence and hedge lines, and building footprints. In some jurisdictions, they contain the fundamental information from which the cadastral maps are prepared. Base maps should be tied to the geodetic network. They are typically prepared using photogrammetric methods and include attributed: points (power poles, fire hydrants, etc.); lines (curbs, ditches, and fences, etc.); and polygons (ponds, building footprints, etc.). Base map development in urban areas requires very sophisticated techniques and equipment. This work is typically performed by professional photogrammetry firms.

In more rural and remote areas, base map needs may be met by a national mapping program's digital topographic maps or orthophotoquads, or by other orthoimages. Examples are the U.S. Geological Survey's Digital Raster Graphics (DRG's) or Digital Line Graphs (DLGs), and the National Aerial Photography Program (NAPP) orthophotos.

Another key map layer comprises elevation data. An advanced GIS should contain a digital terrain model (DTM), or digital elevation model (DEM) that will enable a three-dimensional representation of the ground. Thus, the assessor can visualize geographic features such as flood plains or view lots. The DEM/DTM will also provide the foundation for development of orthophotos (orthorectification). The traditional DEM/DTM product was developed through stereo image models obtained in conjunction with aerial orthophotography. However, many jurisdictions now acquire high-resolution digital elevation data through a separate remote sensing process that employs airborne LiDAR (light detection and ranging) technology.

3.3 Cadastral Map Layers

The cadastral map layers should be tied to the base map layer and should show all parcels in the assessing jurisdiction. Each parcel polygon should be attributed with a unique parcel identifier. Parcel boundary lines should be attributed or annotated with bearing, distance, and curve data. Details on map creation and maintenance are provided in sections 4 through 7.

3.4 Additional Map Layers

A multipurpose cadastre should have a variety of layers. Polygon map layers that can be of great value to the assessor include municipal and taxing district and school district boundaries, appraisal neighborhoods, soil types, zoning, subdivision boundaries, and flood insurance rate areas. Linear map layers may include features such as street centerlines, utility lines, and transit lines. Point map layers may include locations of fire and police stations, public buildings and schools. In smaller jurisdictions, the assessor may be responsible for creating and maintaining some or all of these GIS layers; in a large jurisdiction, they may be developed and maintained by other offices or agencies.

3.5 Parcel Identifiers

Each parcel should be keyed to a unique identification number or code that links the cadastral layer with files containing data such as ownership, value, use, and zoning. The parcel identifier provides a common index for all property records and may help track changes in legal descriptions in a rigorous and more manageable way. Parcel identification systems are detailed in section 8.

3.6 Ownership Information

The current owner, owners, and/or parties of interest should be identified for each parcel. In addition, the basis of ownership (recorded deed, contract, court decree, and so on) should be documented. It is desirable to maintain records of past ownership history. Deeds and other ownership documents should be processed within two weeks of recording (National Research Council 1983, 56), although with adequate staffing and technology, deeds can be processed within twenty-four hours or less. Details on ownership database maintenance are in section 6.

3.7 Imagery

Vertical aerial photographs based on film have long been an essential product for base map development. They are being increasingly replaced by digital images from aircraft. Imagery has greater value when it has had all distortions removed so that it closely matches the geodetic control, can serve as a base map, and meets the measurement tolerances required for the cadastral layer. Such images are called orthophotos, orthorectified images, or "orthos." Jurisdictions should acquire new imagery of urban areas at least every five years and of rural areas at least every ten years. Jurisdictions experiencing rapid or slow growth may need to adjust this timetable. Aerial imagery (and photogrammetric work done to create base maps) should meet industry recognized standards for scale, positional accuracy, resolution, and other requirements (URISA/IAAO 1999; U.S. Geological Survey 1986; Federal Geographic Data Committee 1996, 1998a, 1998b; and American Society of Photogrammetry and Remote Sensing 1989).

3.8 Map Products

The assessor should make cadastral data available in a variety of formats. Providing Internet maps can allow easy public access; an Intranet can give similar access to all offices in the jurisdiction; a virtual private network (VPN) can facilitate data dissemination and sharing with stakeholders at remote sites. No matter how advanced the capabilities of the office, a set of current printed maps should be available to the public and staff.

Digital cadastral maps, whether viewed on-screen or in printed form, should include the following elements:

- Boundaries of all parcels
- Parcel identifiers
- Parcel dimensions and areas
- Easements that influence value
- Subdivision or plat boundaries, as well as block and lot numbers
- Boundaries and names of political subdivisions, such as counties, towns, townships, and municipalities
- Boundaries and names of geographic subdivisions, such as sections, townships, government lots, land districts, and land lots
- Locations and names of streets, highways, alleys, railroads, rivers, lakes, and other geographic features

Printed maps should include other basic information: a map sheet number, title block, map scale, map legend, north arrow, key or link to adjoining maps, quality standard achieved, update log, and a disclaimer.

3.9 Facilities and Equipment

Cadastral mappers and deed processors should have a minimum of 100 square feet (10 square meters) of workspace per person. Additional adequate space should be provided for specialized equipment and storage. The process of converting from manual to digital maps may create a temporary need for additional space if the project is performed in-house; see *Standard on Facilities, Computers, Equipment, and Supplies* (IAAO 2003).

3.10 Program Management

Responsibility for mapping program management should be clearly assigned. Managers must ensure that map products meet assessment needs. A manager's duties may include

- Producing new cadastral and associated map layers (see sections 4 and 5)
- Maintaining existing layers and ownership records (see section 6)
- Controlling quality of map production and maintenance (see section 7)
- Contracting for mapping services such as aerial imagery
- Coordinating map layer responsibilities with other stakeholders
- Sharing and selling map products
- Creating and maintaining metadata that describes map products
- Public relations with the land information community and the public
- Purchasing hardware and software
- Creating and maintaining procedure manuals
- Staying current with national and industry standards
- Training personnel
- Creating and maintaining budgets

3.11 Staff and Training

An effective digital cadastral mapping and deed-processing program requires approximately one staff person per 10,000 to 20,000 parcels. This number may be modified depending on the following factors:

- Degree of automation and efficiency in deed processing and mapping work flows

- Economies of scale in larger jurisdictions
- Need to create or recreate digital map layers
- Volume of deed processing work
- Ratio of ownership name changes to transfers that create new parcels.
- Volume of new subdivision and condominium plats filed
- Need to respond to public requests for map and ownership information
- Reliance on contracted mapping services
- Need to create and maintain layers for non-assessment purposes, such as zoning, transportation planning, and emergency response
- Ease of deed processing, especially if transfers contain an accurate parcel identifier

All mapping personnel should receive training in procedures that are appropriate to the jurisdiction. At a minimum, mapping and deed-processing staff should understand the engineering basis of highway and railroad rights-of-way, the surveying basis of boundary creation and description throughout the history of the jurisdiction, and appropriate legal principles of boundary and title law. Once these basic competencies have been achieved, staff should be trained in techniques of mapping with coordinate geometry (COGO), computer aided drafting (CAD), and/or GIS software.

3.12 Procedures, Standards, and Records

A procedure manual for deed processing, as well as for the production and maintenance of cadastral and other map layers, should be developed to ensure that this work is accomplished in a uniform manner. The manual should include detailed standards for map layers and associated databases. It must be continually maintained to reflect procedural changes. In accordance with applicable statutes and ordinances, records used in preparing and maintaining the maps should be retained. These map creation and maintenance processes should be included in metadata that accompany map layers. The Urban and Regional Information Systems Association (URISA) has published a complete digital cadastral mapping procedure manual (URISA 1999).

4. Preparation for a Digital Cadastral Mapping Program

Extensive preparation, planning, and testing are necessary before fully embarking on a new or revised digital mapping program. An introductory level guide to many of these issues has been published (URISA/IAAO 1999); a much more detailed guide is also available (FGDC 1994).

4.1 Needs Analysis

Adequate preparation is essential before a new digital mapping program is undertaken or an existing one is revised. The jurisdiction must first evaluate the assessor's mapping needs, with outside assistance if needed. This analysis should include the following steps:

- Review applicable statutes, rules, regulations, and standards
- Inventory office functions, practices, and resources
- Determine the type of finished product and the accuracies desired and required
- Evaluate existing and needed personnel, facilities, software, hardware, and operating systems
- Determine the funding available

This process should then be extended to the entire jurisdiction and to potential stakeholders and end users. At that point, decisions should be made on the following factors:

- Type of digital maps to create (see section 4.2)
- Need for cooperation with other entities that have
  - already created useful map layers
  - want access to cadastral map layers
- Mix of in-house versus contracted work required to accomplish goals
- Optimal work flow
- Technical specifications for the digital map layers
- Preliminary schedule for the work

4.2 Selection of Type of Digital Cadastral Map

Based on the needs analysis, a type of digital cadastral map must be selected. In general, there are five types of digital maps, ranging from scanned images of the manually prepared legacy maps to maps created through a parcel data model. The desired quality of the digital cadastral map layer is a critical decision depending on budget and goals. A jurisdiction might decide to proceed through all five types over a period of years. However, the fifth type, based on a parcel data model, is the best and should be the goal of all jurisdictions.

4.2.1. Scanned Maps

Existing legacy paper maps or drafting film sheets can simply be scanned into a raster image. These can be difficult to maintain in this raster form, and do not have linked data, but can be easily accessed and shared by anyone with a computer. They are relatively inexpensive to produce, with minimal training and software needs. They also can perpetuate problems that result from legacy maps that were not based on a geodetic network, or were subject to compilation errors. Such maps can be useful during the migration to the next three types of maps (4.2.2, 4.2.3 and 4.2.4), and they can become valuable historical records documenting the end of manual map maintenance, and the start of digital mapping.

4.2.2. Scanned and Georeferenced Maps, with Data Points

Such scanned maps may be referenced to a geodetic control network, so they can be displayed with other georeferenced data layers. These are difficult to maintain, but easily shared. The scanned maps can have a data point placed in each parcel's approximate center (centroid). The attributes of these data points—such as owner name, situs address, assessed value and property characteristics, can be displayed and queried.

4.2.3. Trace-Digitized Polygons

Digital polygons can be created by tracing images (orthophotography or scanned images of hard copy maps) on a large high-resolution monitor (heads-up digitizing) or on a digitizing table. The resulting cadastral layer can be adequate for many appraisal and planning analysis functions; however, parcel boundary lines do not have bearing and distance attributes and are usually less accurate than lines created with COGO methods. If manual maps with parcel identifiers and bearing and distance annotation have been scanned and georeferenced (as in section 4.2.2), they can be displayed as a background layer to the traced polygons. Beginning at this level of digital cadastral maps, the vector data (such as parcel lines) can be displayed on top of raster images (such as aerial photographs); this is a powerful tool for assessment purposes.

4.2.4. COGO'd Polygons

Metes and bounds on source documents, such as deeds and plats, can be used to create parcels through coordinate geometry methods that process bearing, distance, and curve attributes to describe lines. Such maps can be the most accurate and useful if the survey data is accurate and reliable, and they are designed to retain the input bearings and distances as attributes to the parcel lines. Parcel boundaries defined without bearing and distance information can be created by digitizing or transferring base map lines as described in 4.2.3.

4.2.5 Parcels Created within a Data Model

The most sophisticated digital cadastral map system does not use individual map layers; instead, it uses a data model that defines spatial relationships (topological rules) between different components and layers, creating an integrated suite of layers. An example could be made of a subdivision. First the subdivision exterior is mapped; then blocks are mapped, which must fit within that exterior; and finally lots are mapped, which must fit within the blocks. Rules may also be set for individual parcels, which must close, and cannot have gaps or overlaps unless desired. A publication is available which exhaustively describes the FGDC's parcel data model (von Meyer 2007).

4.3 Technical Specifications

Specifications should be prepared that clearly define technical aspects of the aerial imagery or digital mapping project. They should include such items as:

- Quality and quantity of the mapping products
- Layers to be delivered, and associated data
  - This should include, at a minimum, the map portions of the Cadastral Core Data Set standard of the FGDC (FGDC 2006a): Metadata, Parcel Outline, Parcel Centroid, Parcel Number, and Parcel Area
  - Layer and data field names should follow relevant standards, including the FGDC's Cadastral Data Content Standard (FGDC 2008)
- Positional accuracy requirements
- Geographic areas to be flown or mapped
- Tiling scheme for data (typically township, range, and section, UTM grid cells, or state plane coordinate grid cells)
- Preliminary activities to be performed (e.g., the establishment of horizontal and vertical ground control)
- Map layers to be produced
- Data to be captured as attributes or annotation
- Sources of data to be used
- Topology rules for use in data models
- Procedures for quality control and product acceptance
- Designs for printed products and format for digital map files
- Documentation of processes
- Metadata to be provided

4.4 Pilot Project

Any major mapping or re-mapping program—whether conducted in-house or under contract—should begin with a pilot project. This should focus primarily on representative areas of the jurisdiction, not on the easiest or most difficult to map. Completing a pilot project provides guidance on technical specifications, training needs, fitness of hardware and software, need for outside assistance, program costs, effectiveness of quality control, and work schedule.

4.5 Contracting for Mapping Services

Consideration should be given to whether the new map layers will be prepared in-house or obtained from an outside source. Many assessing offices do not have the expertise or resources necessary to plan for and create digital cadastral maps. In that case, local, regional, state, or provincial agencies may be available to provide assistance. If this is not possible, the jurisdiction must either acquire needed personnel and equipment or contract with a professional mapping firm for the production of map layers. Adequate staff time must be allocated to quality control (see 7.2.). Adequate quality assurance mechanisms must be in place to check the final results. The jurisdiction or assessor should become familiar with accepted contracting procedures, such as those contained in the IAAO *Standard on Contracting for Assessment Services* (2008).

5. Digital Cadastral Map Creation

5.1 Assembling Source Data

The first step in creating a new or revising an existing digital cadastral map layer should be to assemble all relevant information. This includes the following:

- A list of the parcels in the area to be mapped
- Maps of taxing district and municipal boundaries
- Geodetic control network information
- All General Land Office (GLO), Dominion Land Survey, and Bureau of Land Management cadastral survey plats and field notes in areas covered by a township, range, and section system
- Railroad, highway and, utility route surveys
- Subdivision, town site, township, and town plats and surveys
- Private land surveys and associated corner records
- Current orthoimagery of the area
- Deed descriptions for unplatted parcels and for parcels that vary from lot and block boundaries
- Court decisions that affect parcels in the area to be mapped
- Relevant base map data, such as edge of pavement, street and railroad centerlines, water features, and fence and field lines
- Information on rights-of-way, whether dedicated by plat, purchased in fee, vacated, abandoned, or unopened and, if required, held as an easement
- Information on utility easements, if required
- Previous maps on vellum, paper, drafting film and in digital form
- Other imagery of the area, from non-ortho or older photographic sources, especially if it is in paper form and has parcel boundaries
- Highway maps, street name databases, and other sources of information for official names of roads
- Sources of geographic names
  - National map series topographic maps, such as U.S. Geological Survey topographic quadrangles
  - Geographic name databases (for example, the U.S. Geographic Names Information System)

5.2 Mapping Parcels in the COGO and Data Model Environments

COGO-based mapping should employ the sources listed in section 5.1. Creation of the digital cadastral map layer should proceed in the following general sequence:

- The geodetic control layer
- The township/range/section, UTM grid, municipal boundary, or other tiling framework
- Well-surveyed linear features affecting large areas, such as highways, railroads, or canals
- The largest and best-surveyed areas of parcels, such as subdivisions and townsites
- Parcels with good quality metes and bounds descriptions
- Those parcels whose boundaries must be traced or transferred from base map elements, such as creeks and fences

If base map data are insufficient for tracing, there should be field checks and discussions with owners to establish agreed-upon boundaries.

In the data model environment, a similar procedure is followed, moving from larger areas to smaller, following established topology rules.

5.3 Problem Resolution

Digital cadastral map layers commonly contain areas in which individual parcels or groups of parcels have gaps, overlaps, or closure errors. Decisions on resolving such problems should be made with great care, based on the following:

- Knowledge of mapping and boundary law, such as principles of junior and senior rights, water boundaries, and adverse possession
- Knowledge of surveying techniques and technology, such as the need to rotate descriptions to a common basis of bearing

- Knowledge of land division systems affecting the jurisdiction, such as the evolving PLSS and/or Spanish, French, Dutch, or English colonial practices (Price 1995) in North America.
- Understanding of the capabilities and limitations of the software being employed, such as the ability to snap, extend, trim, generalize, adjust closure by compass rule, and use fuzzy tolerances
- Good judgment and common sense

The goal should be to produce a final cadastral map layer with seamless, clean polygons without gaps or overlaps. It may be necessary to work with property owners, attorneys, private surveyors, and county surveyors to resolve problems and achieve this goal.

Decisions on problem areas should be well documented. This may be done on worksheets (which should be filed and preserved) or in text files. The best practice for documentation would be annotations or memo fields attached to points, lines, or areas on the map.

6. Mapping System Maintenance

Digital cadastral map layers and ownership databases should be maintained on a continuous basis by qualified personnel. Map and ownership data represent a substantial capital investment, which can be lost unless all changes and corrections are made on a regular basis. The Bureau of Land Management (BLM) has developed a complete system for maintaining digital cadastral map layers and associated ownership databases. Its National Integrated Land System (NILS) (BLM 2001) is based on a work flow that can be adapted for use in local government cadastral programs.

6.1 Ownership Maintenance

Maintenance of ownership databases involves the following:

- Collecting all relevant deeds, contracts, plats, court cases, owner requests, and other muniments of title
- Identifying the parcels these documents affect
- Determining whether the documents have any effect, are simple ownership changes, or require changing parcel boundaries through splits, combinations, property line adjustments, new subdivisions, or map edits
- Interacting with property owners, surveyors, attorneys, title insurance staff, and other land information professionals to resolve problems when necessary
- Entering the changes in appropriate databases
- Controlling quality of the data (see section 7.2.)

6.2 Cadastral Layer Maintenance

Maintenance of the digital cadastral map layer involves the following

- Obtaining information about needed changes (through the processes in section 6.1)
- Making required changes of parcel lines, parcel identifiers, and associated data
- Performing quality control (see section 7.2.)
- Distributing map information to appropriate parties
- Constantly correcting and improving the cadastral layer when new and more accurate data become available
- If needed, remapping areas or map tiles at a higher scale or with greater accuracy

6.3 Backing Up Data

For computerized map and ownership data, a back-up copy should be made at the end of each workday and periodically moved to be stored at a remote site.

7. Quality Control

In both creation and maintenance of digital cadastral maps and ownership databases, accuracy must be ensured through adequate quality control.

7.1 Map Accuracy

Digital cadastral map layers should be tested for spatial accuracy, and the results should be documented in metadata. Map accuracy is typically expressed in one of three ways.

- The National Map Accuracy Standard (NMAS) (U.S. Bureau of the Budget 1947) for large-scale maps typically requires that 90% of all well defined points on a printed map should vary no more than 1/30 of an inch from their true location. Thus, if a map is drawn or compiled at a scale of one inch equals 100 feet, then an easily identified point on the ground should be within 3.33 feet of its true location. The NMAS is most appropriate for paper maps which are only viewed at the printed scale. This standard would only be applicable to the digital mapping environment if accuracy was described for a particular map scale (for example, “This map layer meets NMAS at a scale of one inch equals 100 feet”).
- The American Society of Photogrammetry and Remote Sensing (ASPRS 1990) developed standards that define three classes of positional accuracy, based on limiting root mean square error. The quality standard is based on full (ground) scale and is well suited to large scale base maps prepared through digital orthoimagery.

- The National Standard for Spatial Data Accuracy (NSSDA) (FGDC 1998b) presents a rigorous statistical methodology to evaluate the positional error observed when a sample of well defined map points varies from their true geospatial location. However, the standard does not provide positional accuracy thresholds; it merely provides a way of describing the accuracy of a digital map.

A major problem with any cadastral map, manual or digital, is that positional accuracy tends to vary within a single map layer. In the township, range, and section environment, parcels close to a section corner tend to be mapped more accurately than parcels in the center of a section. In the metes and bounds environment, a new subdivision's parcels will be very accurate, but nearby parcels described by fields, fences, creeks, and roads may be very inaccurate. Thus, while accuracy should be field tested and documented in metadata, accuracy measures must be used judiciously; their greatest value may be in pointing to areas where additional survey work or map effort should be employed.

One last consideration is that no one accuracy standard meets all needs. In an urban environment, accuracies of one foot or less (0.25 meters) may be necessary. In rural areas, it may be sufficient to specify an accuracy of +/– 8 feet (2 meters).

7.2 Quality Control

Quality control is a vital process in both map creation and maintenance. Software should be designed and configured with built-in testing for data integrity and validity. For mapping purposes, this is easier in the parcel data model environment.

In map creation, tests should be conducted and queries performed to ensure that all relevant documents (Section 5.1.) are reflected in parcel boundary layers. Queries should be run to ensure that all parcels in tabular databases are found in the digital cadastral map layer, and vice versa. Polygon parcel layers should be viewed with orthoimagery and older scanned maps in the background, to visually inspect for misregistration. Parcel area attributes on the digital cadastral map layer should be compared to areas in tabular databases, for staff review of significant differences.

In map and ownership maintenance, tests should be conducted and queries performed to ensure that all relevant documents (Section 6.1.) have been gathered and properly processed, with correct ownership and map changes made. Near-perfect correlation must be maintained between parcels in tabular databases and parcels in digital map layers.

8. Parcel Identifiers

The greatest assessment use of a digital cadastral mapping system is not just maintaining parcel and ownership information, but using it in the appraisal process. To do so, parcels in a digital cadastral map layer must be linked to assessment data such as year built, square feet, sale price, sale date, etc. The key link between parcels and tabular data is the parcel identifier (also referred to as the parcel identification number, PIN, or parcel ID). A PIN uses a number or code instead of a complete legal description to uniquely identify one parcel.

The jurisdiction's tax parcel number should be legally defined and recognized as the official reference to all documents or data for each parcel. All jurisdictions in a state or province should use the same primary system of parcel identification. Because agencies have different needs, various secondary identifiers also may be used to index parcel data; however, all of the secondary identifiers must be cross-indexed to the legally recognized, unique tax parcel identifier (National Research Council 1983, 63).

8.1 Desirable Characteristics

Many types of parcel identifier are in use. A PIN, in use or proposed, should be judged based on six attributes.

8.1.1 Compliance with Standards

If a state, regional, or local parcel identifier format has been adopted, a jurisdiction should follow it. In addition, various national PIN formats have been proposed (PRIA 2003), but not yet mandated.

It is likely that, at least initially, a "national parcel number" would simply add an appropriate Federal information processing standards (FIPS) code, developed by the National Institute of Standards and Technology, to the front of each jurisdiction's existing PINs (National Academy of Science 2007). In 1995, The Federal Geographic Data Committee (FGDC) Cadastral Subcommittee developed a *Cadastral Data Content Standard* (2003) that identifies core parcel data useful to many stakeholders and suggests that this information be captured and maintained by assessors. The core data elements are described in Appendix A.

8.1.2 Uniqueness

Uniqueness is the most important attribute of a PIN. It refers to a one-to-one relationship between a parcel and its identifier. An identifier should be assigned to one and only one parcel.

8.1.3 Permanence

Parcel identifiers should be permanent and change only when absolutely necessary. This is especially important when stakeholders such as planning departments or tax payment tracking services link their own databases to the assessor's.

8.1.4 Simplicity and Ease of Use

Parcel identifiers should be easy to understand and use and have as few digits as possible. A parcel identifier that is uncomplicated and easily understood helps to reduce errors in its use.

8.1.5 Ease of Maintenance

The parcel identification system should be easy to maintain and should efficiently accommodate changes, such as subdividing or consolidating parcels.

8.1.6 Flexibility

The parcel identification system should be reasonably flexible. It should be capable of serving a variety of uses: not just land parcels, but multi-story condominiums, sub-surface rights, leases, easements, and so on.

8.2 Kinds of Parcel Identifiers

There are five basic types of parcel identifiers, described as follows. The first two types, which incorporate clues to a parcel's geographic location, are recommended for assessment purposes.

8.2.1 Geographic Coordinate Systems

The geographic coordinate system is a method of locating a point on the Earth's surface based on its distance from each of two intersecting grid lines known as *x* and *y* axes. These grid lines can be based on latitude and longitude, the Universal Transverse Mercator (UTM) system, or state plane coordinates. Parcel identifiers using this system are composed of the coordinates for a single point, usually the parcel centroid.

Parcel identifier systems based on geographic coordinates are easy to maintain, because new numbers are quickly assigned by picking parcel centroids. They are easy to use in the field, because the PIN can help locate the parcel when using a GPS. Such PINs also meet the criteria of uniqueness and permanence.

However, geographic coordinate-based PIN's may not meet the criteria of simplicity, because a complete parcel identifier could be very long. This is partially due to the need to include not just x and y coordinates, but a *z* (elevation) coordinate as well. This is required for multi-story condominiums and apartments, where parcels at different levels could have the same x-y centroid. The elevation problem could also extend to sub-surface parcels, such as underground parking or mineral rights.

8.2.2 Rectangular Survey System

This system of parcel numbering is based on township/range/section systems such as the United States PLSS. Parcel identifiers based on a rectangular survey system are developed by using the township, range, section, quarter-section, and quarter-quarter-section numbers, along with individual parcel identifiers assigned to each tract. This kind of PIN provides an approximate geographic location of each parcel, is relatively easy to understand and maintain, and meets the criteria of uniqueness and permanence. However, it could never be the basis of a national parcel numbering system, because many areas do not use a township/range/section system.

8.2.3 Assessors' Map-based Systems

A map-based system is relatively simple and easy to use. Under this system, the assessment map itself is incorporated into the parcel identifier. The parcel identifier consists of a map (or page), block (or group), and parcel number such as 32–02–16, where 32 represents the map on which the parcel is found, 02 indicates the block on the map, and 16 identifies the parcel in that block. Map-based identifiers may, to some extent, reference a geographic area and are convenient for use with printed maps in the field. However, they have limited usefulness in the digital cadastral mapping environment, where the goal is one seamless map of the entire jurisdiction, rather than individual sheets.

8.2.4 Name-related Identifiers

Name-related identifiers use the names of individuals claiming an interest to a parcel as the parcel identifier. A common example of this is the use of name codes in the grantor–grantee index. Use of such identifiers is discouraged because they do not meet the criteria of permanence and reference to geographic location.

8.1.3 Alphanumeric Identifiers

An alphanumeric code is often an arbitrary number associated with the parcel. An example is the sequential numbering system in a tract index. This may have advantages of permanence and ease of maintenance (new parcels are simply assigned the next available number). However, ease of use is limited, as adjoining parcels could have wildly different PINs.

8.3 Assignment of Parcel Identifiers

Parcel identifiers should be assigned to all parcels, whether taxable or exempt, during the initial phase of a digital cadastral mapping program. These PINs should be considered provisional until the mapping program has been completed and all maps have been formally approved.

Maintenance of parcel identifiers should be done on an ongoing basis by a single agency as new parcels are created. This raises of the question of assigning PINs to an existing ("parent") parcel which has been divided ("split") into two or more ("child") parcels. Some jurisdictions retain the original PIN of the parent, and only assign a new number to each new child. However, since the parent parcel's boundaries are now changed, the parent should also be assigned a new PIN, and its original PIN should be retired. In this case, the parent's new parcel identifier puts stakeholders on notice that it has changed in some way.

Glossary

This glossary defines mapping terms used in this standard and its appendices and other commonly used mapping expressions. Some of these definitions were compiled from the textbook, *Definitions of Surveying and Associated Terms* (ACSM 2005), and are used with permission of the publisher.

Assessment map. (See *cadastral map.)*

Base map. A map containing the background upon which geographic data is overlaid. Contains basic survey control and reference framework for integrating all of the other map features of a particular area. Orthophotos are commonly used as a cadastral base map.

Bearing. Direction of a line measured from north or south to east or west, not exceeding 90 degrees.

CAD. Computer aided design. A digital software technology used for the design, drafting and presentation of graphics. It is commonly employed in drafting work for engineering and manufacturing, and may also be used to design maps.

Cadastral map. A map showing the boundaries of subdivisions of land, usually with the bearings and lengths thereof and the areas of the individual tracts, for the purposes of describing and recording ownership. A cadastral map may also show culture, drainage, and other features relating to the value and use of the land.

Compilation. (1) Cartography: The production of a new or revised map from an existing map, aerial photograph, survey, or other source material (see *delineation*). (2) Photogrammetry: The production of a map or chart, or portion thereof, from aerial photographs and geodetic control data, by means of photogrammetric instruments, also called stereocompilation.

Contour line. A line drawn on a topographic map connecting points with equal terrain surface elevation.

Control (ground and geodetic). A system of points which are used as fixed references of position (horizontal) or elevation (vertical) or both. Ground control are points obtained from ground surveys. These points can be used to rectify the accuracy of cartographic products to the actual area on the ground that is represented. Geodetic control takes the size and shape of the earth into consideration.

Coordinates. Linear or angular quantities that designate the position of a point in a given reference frame or system. The x and y values, or three-dimensional x, y & z values that define a location in a planar or three-dimensional coordinate system.

Data model. A generalized, user-defined view of data representing the real world. A description of the structure of a database. It describes how data is represented and accessed.

Delineation. The visual selection and distinguishing of map worthy features by outlining, or on a map manuscript (as when operating a steroplotting instrument); also, a preliminary step in compilation.

DEM Digital Elevation Model. A digital representation of bare-earth elevations (z values) that is referenced to a common datum. Digital elevation models are typically used to represent terrain relief without vegetation, buildings or improvements.

DTM Digital Terrain Model. A digital representation of the Earth's surface. Its construction includes a basic elevation model (i.e. a DEM) that is typically enhanced with break line data to accentuate abrupt changes terrain features features, such as pavement edges, road crowns, riverbanks, ridgelines, creek beds, etc.

Feature. Points, symbols, lines, and areas on a map representing natural and man-made geographic features. An object in a geographic or spatial database with a distinct set of characteristics.

Geocode. A code (usually numerical) used to locate or identify a point on a map, such as the center of a parcel.

Geodetic coordinates. The quantities of latitude and longitude that defines the position of a point on the surface of the earth with respect to the reference spheroid, frame or system. (See also *coordinates*.)

Government lot. A partial section of land established, measured and computed by the U.S. Government's survey of the public lands. Often used synonymously with "fractional lot" or 'fractional section".

Grid. A uniform system of rectilinear lines superimposed on an aerial photograph, map, chart, or other representation of the earth's surface; used in defining the coordinate positions of points.

Index map. (1) A map of smaller scale on which are depicted the locations (with accompanying designations) of specific data, such as larger-scale topographic quadrangles or geodetic control. (2) Photogrammetry: A map showing the location and numbers of flight strips and frame images.

Land information system. A system for capturing, retaining, checking, integrating, manipulating, analyzing and displaying data about land and its use, ownership and development.

Layer. Set of related geographic features, such as streets, parcels, or rivers, and the attributes (associated characteristics of those features) logically organized into groups that can be displayed independently.

LiDAR. Light detection and ranging. A remote sensing tool for generating very accurate digital surface models. It uses an aircraft mounted sensor that emits rapid pulses of infrared laser light to determine ranges to points on the terrain below. The point data may be used to construct a digital surface model (DSM), digital elevation model (DEM), or digital terrain model (DTM.).

Lot. A plot of land, generally a subdivision of a city, town, or village block, or some other distinct tract, represented and identified by a recorded plat.

Map. A representation (usually presented on a two dimensional medium) of all or a portion of the earth or other celestial body, showing relative size and position of features to some given scale or projection. A map is a model that may emphasize, generalize or omit the representation of certain features to satisfy specific user requirements.

Map projection. An orderly system (mathematical model) to portray all or part of the earth, which is an irregular sphere, on a planar or flat surface. Some distortions of conformality, distance, direction, scale, and area will always result from this fitting process. Examples include the Mercator and the Lambert Conic Conformal Map Projection to name a few.

Monument A permanent physical structure marking the location of a survey point or boundary line. Common types of monuments are inscribed metal tablets set in concrete post, solid rock or parts of buildings; distinctive tone posts; and metal rods driven in the ground.

Orthophotograph. A photograph having the properties of an orthographic projection. It is derived from a conventional perspective vertical photograph (for mapping purposes) by simple or differential rectification so that image distortions caused by camera tilt and relief of terrain are removed.

Overlay. A map recorded on a transparent medium that may be superimposed on another record; for example, maps showing original land grants (or patents) prepared as tracing cloth overlays so that they can be correlated with maps showing the present ownership. Also, any of the several overlays that may be prepared in compiling a manuscript map; usually described by name, for example, lettering overlay.

Parcel. A single, discrete piece of land having defined physical boundaries and capable of being separately conveyed.

Photo delineation. The selection and identification of mapworthy features on a photograph or digital image.

Photogrammetry. The art, science and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring and interpreting images and patterns of electromagnetic radiant energy. (See also orthophotography)

Plane rectangular coordinates. A system of coordinates in a horizontal plane used to describe the positions of points with respect to an arbitrary origin by means of two distances perpendicular to each other. (See also *coordinates.*)

Planimetric map. A map that presents only the horizontal positions for the features represented; distinguished from a topographic map by the omission of relief in measurable form.

Plat. A diagram drawn to scale showing all essential data pertaining to the boundaries and subdivisions of a tract of land, as determined by survey or protraction.

PLSS. Public Land Survey System. A rectangular survey system used in much of the United States dividing land areas into townships of 36 one-square mile sections. Sections can be further subdivided into quarter sections, quarter-quarter sections, or irregular government lots.

Point. Single x, y (optionally z) location points in space. Dimensionless geometric feature having no other spatial properties except location. Many different natural and man-made features are modeled as points in a spatial database including trees, hydrants, poles, buildings, parcel centroids etc.

Positional accuracy. The degree to which the coordinates define a point's true position on the earth's surface.

Rectification. The process of projecting the image of a tilted aerial photograph onto a horizontal reference plane to eliminate the image displacement caused by tile of the aerial camera at the time of exposure.

Remote sensing. The process of obtaining information about an object while physically separated from it. Practically, this is a term used to describe the process of using sensors mounted on satellites to capture images and to observe the Earth's geology, surface and atmosphere.

Resolution. (Spatial Resolution). 1) The minimum distance between two adjacent ground features that can be detected by remote sensing. 2) The smallest possible map feature that can be accurately displayed at a specified map scale.

Scanning. Capturing an image using an optical or video input device that uses light sensing technology. A process by which photographs, printed data, or drawn maps are converted to a digital format.

Spatial. Relating to space or a space. Refers to the shapes, location, proximity, and orientation of objects with respect to one another in space.

State plane coordinate systems. A series of grid coordinate systems prepared y the U.S. Coast and Geodetic Survey for the entire United States, with a separate system for each state. Each state system consists of one or more zones. The grid coordinates for each zone are based on, and mathematically adjusted to, a map projection. (See also *coordinates*.)

Topology. A set of defined relationships between links, nodes, and centroids. Topology describes how lines and polygons connect and relate to each other. Among the topological properties of concern in GIS are connectivity, order and neighborhood.

Vector. Vector data is the storage of X, Y, Z coordinates connected to form points, lines, areas, and volumes. A vector can be a straight line joining two data points.

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Appendix. Core Parcel Data Elements

Land record/GIS integration makes strong economic and business sense. With integration, an assessing jurisdiction's land records, GIS, tax/assessment/valuation and addressing data are more valuable together! The collective records are much more useful to more people. With key record cross-referencing beginning before instrument recordation, Land Record/GIS integration begins near the start of many key workflow processes. To allow for such integration, assessors should consider capturing Parcel Core Data to the extent practical.

Parcel Core Data describes the minimum set of attributes about land parcels and associated reference data that can provide essential information to meet business needs without publishing the complete set of parcel characteristics.

Background

The Federal Geographic Data Committee (FGDC) Cadastral Subcommittee completed the Cadastral Data Content Standard1 in 1995. [ADD language referring to core date listed below] This information was published in the May, 2003 FGDC Cadastral Data Content Standard version 1.3. (http://www.nationalcad.org/data/documents/CADSTAND.v.1.3.pdf)

In 2000 the Subcommittee began a series of studies on the uses for and applications of cadastral data. Many business needs were studied , includinghurricane and wildland fire response, energy management needs, uses of parcel data by federal agencies and most recently mortgage and real estate analysis. From this body of work the Subcommittee defined a limited set of attributes (core parcel data) that provide a platform supporting multiple business needs.

It is important to recognize that publication data are not the same as operation and maintenance data or production data. Production data are structured to optimize maintenance processes are integrated with internal agency operations, and contain much more detail than publication data. Publication data are a subset of the more complete production data and are intended to be integrated across jurisdictional boundaries and be presented in a consistent and standard form nationally. To the extent that assessors consistently capture and make available Parcel Core Data, this goal will be attainable.

Parcel Core Data provides a platform thatrecognizes a basis upon which many other themes and data sets are referenced. For example land parcel data could be used to spatially enable business license information, voter registration or health statistic information.

The parcel core data speaks to the standardization of the small, but most crucial set of attributes. Jurisdictions may expand upon the minimum set and some applications may need additional attributes, but having a short list of standardized attributes should make linkage or other data sets possible and allow for the expansion and individualization of published data.

There are two other important notes about the cadastral data platform. Parcel data changes frequently and needs to be updated regularly. Many of the initial needs of the business applications studied can be met with annual parcel updates, but in the end all business applications need current data. Therefore, even though assessors' records may be subject to updating on an annual cycle to accommodate property tax needs, unlike many other spatial framework data sets, cadastral information to be used to satisfy multiple business needs should be continually updated. The second note is that all spatial data should have accompanying metadata describing the source agency, contact information, spatial referencing and accuracy and currency.

The following is the list of attributes defined in the core data set. [This list was developed by FGDC and assessors should try to capture this information and make this core data set available.] In the physical file structure the address elements are defined as individual components and as a single concatenated field.

Metadata—The metadata will contain information about the entire data set such as the data steward, the parcel contact, a description of the basis for the assessment system (sale price, use, market value etc), the date of the file, information on interpretation of the assessment classifications and any other metadata that would support the use and application of the information.

Parcel Outline (Polygon)—This is geographic extent of the parcel, the parcel boundaries forming a closed polygon. The parcel geometry may be a polygon or a point. The Parcel centroid and the polygon are not both required.

Parcel Centroid (Point) **-** This is a point within the parcel that can be used to attach related information. This may be a visual centroid or a point within the parcel. It may not be the mathematical centroid as this point needs to be contained within the parcel polygon.

Parcel ID—A unique identifier for the parcel as defined by the data steward or data producer. The parcel identifier should provide a link to additional information about the parcel and should be unique across the data steward's geographic extent.

National Parcel ID—This is a nationally unique identified constructed from either the GNIS code for the jurisdiction or the Census codes plus the local identifier.

Source Reference—This field is often called the Volume/Page or Liber/Page in local records. This is a pointer to, or an attribute describing, the source reference for the parcel.

This could be a deed, plat, or other document reference.

Source Reference Date—The date of the Source Reference, which is essentially the last update date for this parcel. The entire data set may have a last updated date or an "unloaded for publication" date that is different than the specific currency or update date for each individual parcel.

Owner Type—The type of ownership is the classification of owner. In some local governments tax parcels are tagged as either taxable or exempt and the owner classification is not known.

Improved—This is an attribute to indicate whether or not there is an improvement on the parcel.

Owner Name—An indication of the primary owner name, recognizing that there may be multiple owner names or that some owner names may be blocked for security reasons or that some jurisdictions may not allow the distribution of owner names. For publicly held lands the owner name is the surface managing agency, such a Bureau of Land Management, Department of Transportation, etc.

Assessment/Value for Land Information—This is the total value of the land only. The basis of the value, such as market value, resale value, sale price or use value should be described in the metadata.

Assessment/Value for Improvements Information—This is the total value of improvements on the parcel. The basis of the value, such as market value, resale value, sale price or use value should be described in the metadata.

Assessment/Value Total—This information is the total value of the land and improvements. The basis of the value, such as market value, resale value, sale price or use value should be described in the metadata.

Basis of the Values—An indication of the type of values that are provided (taxable, market, assessed or other). This may be included in the metadata if it is the same for all of the records in a data set.

Assessment Parcel Use Code—This is the parcel use classification for the tax parcel based on the classification of the parcel for the purposes of valuation.

Tax Bill Mailing Address—This is the US Postal Service address for the tax bill mailing.

Site Address—This is the street address (site address) for the parcel. If there is more than one, select the first or primary site address.

Parcel Area—The area of the parcel expressed in acres.

Reference

Cadastral Subcommittee. 2003. *FGDC Cadastral Data Content Standard version 1.3*, May 2003, http://www.nationalcad.org/data/documents/CADSTAND.v.1.3.pdf (accessed January 27, 2012).