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Kenneth Dueker
Portland State University

Daniel Kjerne
Portland State University

Lawrence M. Conrad
Portland State University

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ISSUES IN DESIGN OF A MULTIPURPOSE CADASTRE

by
Kenneth J. Dueker
Daniel Kjerne
Lawrence M. Conrad

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Center for Urban Studies
School of Urban and Public Affairs
Portland State University
Portland, OR 97207-0751
(503) 725-4020
(503) 725-5199 FAX
http://www.upa.pdx.edu/centers.html#CUS

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Introduction

This paper summarizes a discussion of some of the technical issues which appeared in a report prepared during January - July, 1985, by a team of researchers from Portland State University's Center for Urban Studies under a contract for the Department of Assessment and Taxation of Multnomah County, Oregon. The complete report also covered user needs as identified through a series of interviews of agencies making use of assessor maps.

At some time in the next two or three years, Multnomah County will be eligible for assistance from the Oregon State Department of Revenue (DOR) in reconstructing its cadastral mapping system. Both the county and the DOR are vitally interested in upgrading their respective capabilities for handling cadastral data. First, though, it will be necessary to thoroughly understand just what is involved in developing and maintaining cadastral maps, and whether the multipurpose cadastre, or a broader land information system, is warrented at this time. The research, and resulting report, are a first step in that process of gaining understanding.

The charge to the investigators implied a need to clarify two issues discussed in this paper:

1) Methods of building base and cadastral layers -- photogrammetric techniques, digitizing available maps, computing cadastral locations from deed and survey information.

2) Update of locational data in non-base layers of a computer assisted mapping system. Upgrading cadastral locations that are dependent on the location of other objects not in the base layer, such as rights-of-way, streams, etc., does not appear to be done very successfully by any known, available mapping systems.

Geographic information system (GIS) technology has been successfully applied in areas such as natural resource management, municipal and private facilities management, regional and urban planning, and emergency dispatching. Cadastral mapping presents some unique technical challenges to this field (not to mention such non-technical factors as the multiplicity of actors and users involved and the impact of funding decisions in the governmental environment). Perhaps the most intriguing problem of cadastral mapping is that of updating locational data -- the data which, ultimately, determines <u>where</u> objects such as property corners and rights of way will be found. This problem may be clarified by reviewing the situation prevailing with assessor maps in manuscript form.

When an assessor manuscript map sheet becomes too worn to update by erasing old lines and adding new ones, or a large number of changes must be made at once (as when a large new subdivision is recorded), or several new, larger-scale maps are to be made from one smaller-scale map, the cadastral cartographer has the job of reconstructing the map from all relevant and available property and engineering surveys, deed descriptions, subdivision plats, vacation ordinances, etc. In this process, the newer surveys and plats are generally assumed more accurate than older ones, and (in general) all surveys are judged more accurate than deed descriptions not supported by a ground measurement. Thus, depending on how inaccurate the older locational information was, the reconstructed map may alter substantially the position of property boundaries for parcels that appeared on the old map.

In Multnomah County, the construction standards for this map system are established by the Oregon State Department of Revenue (DOR) under its authority to provide uniformity in assessment and taxation. The Records Management Division of the Multnomah County Department of Assessment and Taxation is responsible for the construction and maintenance of assessor maps using these established standards. The Department of Assessment and Taxation halted reconstruction of old base maps as a result of budget cuts in 1979. Since that time, the Department has committed its remaining mapping resources to the maintenance of the existing system as best it can.

Without a reconstruction program, new location data -- new surveys, plats, and so on -- are added to the old maps by fitting to the old property boundaries. This often results in the newer (and presumably more accurate) location data being inaccurately portrayed. Some of the old, unreconstructed maps presently used by the County Assessor's office were originally drafted fifty years ago, and the basic framework to which new surveys are added is inaccurate by present standards.

Assessor Map Producer Goals for the Multipurpose Cadastre

In December of 1984, officials of the County Assessor's Department and the County Data Processing Department met with the project investigators in an intensive, four-hour session during which Interpretive Structural Modeling (ISM) methods were used to identify and study the relationships between the clients' goals in developing a multipurpose cadastre. Four overarching goals were identified at that time:

- to eliminate title problems
- to minimize overall costs of developing and maintaining a multipurpose cadastre
- to develop a system or procedural model usable by DOR in other similar situations
- to facilitate inter-agency sharing of geographic information

During the meeting that afternoon, investigators and clients were able to clarify some of the arguments behind each of these goals and to identify some of the assumptions and supporting elements implied.

For the first goal, the most important element was an improved linkage to property and engineering survey data, and ultimately to geodetic control. As the discussion above indicated, map reconstruction in a paper map system resembles what biologists call "punctuated evolution" -- any one map sheet will only be redone at long intervals. Between reconstruction events, anomalies and ambiguities accumulate as "the same" boundaries are remeasured and found significantly different. A computer-aided cadastral mapping system holds the promise of, essentially, a continuous reconstruction of the cadastral layer with less-accurate measurements fitted to more accurate ones rather than the reverse.

For the second and third goals, a common supporting element was that of working with the Oregon State Department of Revenue to develop a cadastral layer, which layer would be maintained by the assessor's office. Overall costs would be minimized if each agency concentrates its resources and expertise in one area of system implementation: the DOR in development of the cadastral layer, and the County Assessor on maintenance.

The most important element supporting the final goal (from the clients' perspective) was the establishment of a uniform base map usable by other agencies, on which they could register their layers of geographic data.

A Typology of Assessor Map Users

During January, February, and March of 1985, the project staff conducted some 40 interviews of public and private organizations using Multnomah County assessor maps. Our goals during this phase of the investigation were to find out current uses of assessor maps and what kind of expectations they have of a multipurpose cadastre. We were also interested in how users visualized their own involvement with a land information system based on a multipurpose cadastre.

Assessor map users fell into four groups: 1) title insurance companies; 2) facilities management and construction; 3) planning and general administration; and 4) public safety. The facilities management and construction category contained both public and private agencies with generally similar needs, so it was further divided into 1) private utilities; 2) public utilities and transportation; and 3) engineering, surveying, and photogrammetry.

We then attempted to categorize the assessor map users' needs in terms of accuracy, map scale, content, and frequency of update.

Title companies need to have assessor maps continuously updated to have the most recent data possible for their title search process. The current formal yearly update system is not adequate for their purposes. The current 1" =100' scale is preferred by the title companies because of readablitiy and familiarity. Accuracy is not a major issue with this group. The maps they provide to customers are considered to be a representation, not necessarily to scale, of the situation and are for general locational purposes only.

Title companies use assessor maps for three basic purposes. First, maps are used as an index for the location of properties and for determining present configuration. This is the most common usage of the system.

Title companies commonly use the assessor maps to help locate parcels during a title search, especially in rural areas. Secondly, the maps are used to cross check lot size and shape. This can reveal changes in lot lines or areas for future research before they issue a title insurance policy. Lastly, the maps are used by the subdivision or land development section within each title company as a starting point in the process of helping developers to locate parcels of land that may be suitable for development. The title companies use the following data types from maps:

Bearing of Lot Lines	Easements
Legal Descriptions	Lot Area
Lot Dimensions	Street Names
Street Vacations	Tax Account Number

Two of the **private utilities** have used the existing assessor map system to construct their own digital base maps. These are currently updated on an ongoing basis. The other two private utilities are presently establishing their own computerized mapping systems and are interested in the possiblity of utilizing the new county base in their own system. The current update system does not, however, meet their needs. The companies update their base maps in order to reflect the status of the ongoing land development process and to allow their engineers to design new service extensions. They need to obtain base map updates at least on a monthly basis. The utilities prefer that the assessor maps be at a scale of 1" =100' for most uses. They prefer that the level of map accuracy be somewhere between ±1 foot and ±10 feet depending upon actual map use.

Private utilities use assessor maps to keep track of property owned and tax payments due, a very time consuming task because of the large number of tax codes (i.e., different property tax rates) and assessed values that the companies must track. In addition, assessor maps are used as either generalized base maps or as one input into a proprietary digital mapping system. The data types currently taken from assessor maps include:

City Boundary	Railroad Rights of Way
County Boundary	Section Corners
Easements	Streams and Rivers
Lakes	Street Names
Lot Dimensions	Street Rights of Way
Lot Lines	Tax District Codes
Property Corners	

Public utility and transportation agencies all need updates more frequently than is currently possible. Continuous updating is the most desirable frequency although some users have indicated that bi-weekly updates would be adequate and, in a few cases, monthly ones would be minimally acceptable. All of the users prefer to have the maps scaled at 1" = 100'. It is often necessary, however, for them to work at 1" = 50' or 1" =20' in heavily developed areas. These drawings are made from surveys tied to found property monuments and represent a potential source for data to upgrade the quality of the mapping system. The accuracy requirements of these users is ±1 foot. They prefer that maps be at least as accurate as the standards set for the State Plane System.

All the agencies and departments included in this category use assessor maps as a starting point for a map development process. They use maps as an index to begin the process of finding parcel owners of record and the accompanying chain of title, listed survey monuments, recorded easements, and other items that may affect the proposed project. The types of data currently being taken from assessor maps by these users include:

City Boundaries	Lot Lines
County Road Numbers	Property Corners
Easements	Rights of Way
General Survey data	Section Corner
Legal Descriptions	Streams and Rivers
Lot Area	Street Names
Lot Dimensions	Tax Account Numbers

Engineering, surveying, and photogrammetry users need to have the assessor map data updated more frequently than is currently possible. Most users desire continuous updates, although some indicated that bi-weekly ones would be adequate and, in a few cases, monthly updates would be minimally acceptable. These users prefer to have the maps scaled at 1" = 100'. They often need to work at 1" =50' or 1" = 20' in heavily developed areas. The assessor's mapping system is not accurate enough to meet some specialized user needs in this group. In general, an accuracy requirement of ±1 foot is acceptable. Most users in this group prefer that locational data fulfill the requirements of the National Map Accuracy standards or the recently proposed ASP standards for large-scale line maps [ASP,1985].

This user group is nearly identical in its needs to the Public Facilities and Transportation subgroup. Maps are frequently used as base maps for preliminary engineering (PE). They are also used as the starting point for surveys and for establishing a chain of title for property. Data types currently drawn from assessor maps by these users includes:

City Boundaries	Lot Lines
County Road Numbers	Property Corners
Easements	Right of Way
General Survey data	Section Corner
Legal Descriptions	Streams and Rivers
Lot Area	Street Names
Lot Dimensions	Tax Account Numbers

Planning and General Administration. The need for map updates varies within this user group and the current system does not necessarily meet their needs. The Planning Departments and the City Auditor need continuous updates. Other departments need updates on a monthly to annual schedule.

The scale of the maps is generally adequate for the presentation of data but several of the departments and jurisdictions must modify it to make changes on existing base maps. Most departments like the ability to take detailed data off the 1" = 100' quarter section assessor maps. But they also need at least some of the data available at other scales. The most commonly used scales are the assessor's 1 inch = 600 feet and METRO (Metropolitan Service District)'s 1" = 2000' and 1" = 4000'. These scales allow users to work at a more generalized level. The accuracy requirements vary with the scale of the map, ±1 foot at 1" = 100' and ±100 feet at 1" = 2000'.
Planning Departments are the heaviest map users, using them at the parcel specific to the jurisdiction wide levels. Other users make less frequent use. Data types currently being drawn from assessor maps include:

Easements	Lot Lines
Jurisdiction Boundaries	Rights of Way
Legal Description	Streams and Rivers
Lot Area	Street Names
Lot Dimensions	Tax Account Numbers

Public safety users require continuous updating, but their accuracy needs are quite a lot less stringent than others, on the order of ± 100 feet. Each of the various agencies requires coverage of their particular area, but none covers the entire county. For updating dispatching maps and the maps used in signing off on partitions and building permits, these users are used to the conventional assessor map scales, especially 1"=100'.

These users take the following data types from the assessor's maps:

Easements	Tax Account Numbers
Jurisdiction Boundaries	Street Names
Lot Area	Street Rights of Way
Lot Dimensions	

A Note on Locational Accuracy Requirements

Many users expressed a need for map accuracies of ±1 foot, while at the same time indicating that they preferred to use maps at a scale of 1" = 100'. Comparing this accuracy requrement to those specified in recent proposed standards for large-scale maps and base maps for multipurpose cadastres, assessor map users' specifications appear much more stringent -- perhaps unrealistically so.

For example, Wilcox [1985] proposes cadastral boundary map accuracy standards which measure the accuracy of location of points relative to the map control used and which take into account the base map publication scale such that "[t]o meet U.S. national map accuracy standards, scales larger than 1/20,000 must have a plotted error less than 1/30 [inch]." At a scale of 1" = 100', this translates to 3.3 feet on the ground, rather than one foot.

The National Map Accuracy Standards mentioned above actually refer to small-scale maps, not large-scale ones. Actually,

> [l]itigation in the courts of California has promoted new interest in the establishment of spatial accuracy standards for 1:20,000 scale or larger line maps. During the court proceedings it became clear that suitable standards for accuracy, based on a clear consensus, using generally understood quantifiable error concepts, and providing a clear

procedure for verification, did not exist. The American Society of Photogrammetry (ASP) [now the American Society of Photogrammetry and Remote Sensing (ASPRS)] has ordered a technical committee to prepare appropriate specifications with the intention of eventually proposing them as consensus standards for map accuracy. [ASP, 1985]

The draft standard proposed by the ASP committee defines procedures which can be accomplished in a clearly understood and theoretically correct manner for testing the accuracy of horizontal and vertical location of mapped points. For comparison with the assesssor map users' requirement, and the standard proposed by Wilcox [1985], the committee's standard for a Class 1 map approximately corresponds to a requirement that 90 percent of well-defined points be within 0.43 mm (or 1/47 inch) of their correct planimetric positions as measured on the map at delivery scale. At 1" = 100', this translates to 2.1 feet on the ground. (Class 2 and 3 maps allow an error magnitude twice and three times as large, respectively.)

The accuracy requrement mentioned by users in interviews would be more appropriately met by Class 1 maps compiled at a scale of 1" = 50'. It seems reasonable to assume that densely built-up areas would be mapped at such a scale. Wilcox [1985] proposes basing a series of map scales on the length of lot frontage prevailing in an area. Thus, an area with lot frontages of fifteen to forty feet would be mapped at 1" = 50' (this type of map to be called "Urban Type I"), while an area with lot frontages of fifty to ninety feet would be mapped at 1" = 100' (an "Urban Type II" map).

Assessor Map User Goals for the Multipurpose Cadastre

Since it would have been impractical to subject all of the more than forty interviewees to the intensive, structured-choice situation of an ISM session, we extracted and distilled user goals for a multipurpose cadastre from the interviews:

- to have assurance of a certain minimal level of locational accuracy (certain users specified mapping accuracy in precise terms)

- to have assurance that costs for hard-copy maps will not increase to prohibitively high levels; that cost of geographic data in other media will be reasonable
- to have county-wide parcel level mapping available in different media, at various scales, in various formats

We found that users' goals for the multipurpose cadastre, as abstracted from interviews, were generally compatible with the MPC agencies' goals in that elements identified (in the discussion above) as supporting the one set also tend to support the other.

(In fact, a careful reading of the two sets of goals reveals that they are, with one exception, restatements of each other from two different points of view: the assessor's goals are formulated with production in mind, the map users' goals have end-use as the focus. The exception was the assessor's goal "to develop a system or procedural model usable by DOR in other similar situations", which did not correspond to any users' goal. Although the people at the ISM session did not perceive this goal as supporting any others in the context of cadastral mapping in Multnomah County, it may be viewed from a larger perspective as supporting goals in the larger community of cadastral system users and developers.)

Thus, the first goal (relating to accuracy of location) is supported by strengthening the linkage between cadastral data and property and engineering survey data, and by strengthening the linkage between survey data and geodetic control data. If implemented as an element in building a multipurpose cadastre, this will also help to reduce, if not eliminate, title problems on assessor maps.

The second goal (relating to costs) can be met by a cost-sharing arrangement with State Department of Revenue in developing a careful, incremental approach to building and maintaining a multipurpose cadastre. On the other hand, users are not supportive of a cost recovery method of finance.

Finally, implementing the multipurpose cadastre as a computerized system would support the third goal, since such a system would be able to produce mapping products in a variety of scales and formats and on media appropriate to users' needs and processing capabilities. The users' goal of having this variety of presentations of base layer data corresponds to the client (MPC provider) agencies' goal of facilitating geographic data sharing.

We also tried to identify goals held in common by both sets of actors -- the MPC "producers" (the County Assessor, Data Processing Department, and perhaps the County Surveyor), and the MPC "users":

- to have assurance of security and accessibility of their own data sets
- to have data available from other agencies in a form compatible to the using agency's processing capabilities

Elements supporting each of these goals, respectively, may be identified as: 1) data distribution, with each agency owning and maintaining its own data set while allowing other agencies access to read it; and 2) user coordination of data communication protocols.

Base layers and cadastral data

Objects in a mapping system may be classified either as having relative location or absolute location (as far as the system is concerned). Objects in the base map, or base layer, have absolute location -- their location is described (for instance) in terms of x-y coordinates (so all the objects in the base layer are located relative to the origin of some coordinate system -- defined as absolute for the system).

Objects in non-base layers have relative locations -- relative to objects in the base layer. Objects having relative location may be located using: one **rule**, one or more **relative objects**, and zero or more locational **parameters**. For most maps and most computerized mapping systems, the rule used is a simple one: apply offsets in the x and y directions from a point in the base layer.

The problem with locating parcels, or attempting to use the cadastral layer as a base map -- that is, to give every property corner an absolute location -- is that property points do not have simple spatial relationships with one another nor with a small set of reference points.

Instead of a situation analogous to a single overlay sheet being placed in relation to another, it is as if each plat or parcel were a separate sheet, referring to different objects for its location. The cadastral cartographer, in constructing an assessor map, is confronted with a pile of deed descriptions, surveys, plats, and ordinances. The rules of evidence are used as a guide for property boundary location. Using them to weigh the evidence, it is possible to end up with a reasonable representation of the position of the parcel boundaries. But some of the boundaries will depend for their location on a survey monument; some on the location of a right of way line or an adjacent property boundary; some on the location of a natural monument such as a water body or ridgeline.

A paper map -- and every conventional computer-aided mapping system -- fails to preserve the complexity of the spatial relationships. This is why, when an assessor map is reconstructed, the cartographer has to go back to the deeds and surveys. The information about the <u>why</u> of the spatial relationships was lost in the translation to ink and paper or digital characters.

The upshot of this is that, for MPC "producing" agencies, location of objects in the cadastral layer has to be treated as a derived value if location accuracy is to be preserved over time. The rule for locating an object, the objects it is related to, and the parameters used to describe the spatial relationship are all subject to change. A more-accurate location for a control point or section corner, a change in a deed reference, or a new survey can have consequences which ramify though a large mapped area. Updating the locations of objects "by hand", as is now necessary, is tedious and prone to error. The MPC must have the capability to not simply read out a stored value, but be able to derive the locations of property boundaries in the same way as they were defined by the cadastral cartographer.

For other users, data from the MPC's cadastral layer can be included in a base layer, that is, one in which the locations of objects (as of a certain date, and to a certain order of accuracy) are described in absolute (x-y coordinate) terms.

A classification of base maps and methods

There has been long-standing debate on the best methods to structure and compile cadastral location data for a multipurpose cadastre. Two authors of the present paper [Kjerne and Dueker, 1984] offered some comments on what we identified as the cadastral base map approach and the planimetric approach to building the base layer for a computerized land record system. More recently, Harvey [1985] identified two methods -- the mathematical and the digitizing -- for building a cadastral data layer. At about the same time, Chrisman and Niemann [1985] identified a geodetic control layer as the essential base layer for a multipurpose cadastre. Table 1 presents an attempt to synthesize these various categorizations and to offer an evaluation of each.

In the table, we present a matrix with columns identifying different categories of base layer content and rows identifying two different methods of entering cadastral location data. In each cell, a qualitative comparison is drawn between the various combinations of base map content and compilation method. The comparison is made in terms of the rate of complilation, accuracy of locational data, and the overall usefulness of the combined base layer and cadastral layer as a reference framework (base layer) for users with other data layers.

		base layer content		
		A geodetic control	B planimetric data	C no base layer
cadastral layer compilation method	1 compute from surveys, deeds, etc.	high accuracy slow rate of compilation good framework	highest accuracy medium rate of compilation best framework	low accuracy slowest rate of compilation fair framework
	2 digitization of maps	fair accuracy rapid rate of compilation good framework	good accuracy rapid rate of compilation good framework	lowest accuracy rapid rate of compilation fair framework

Table 1. Base Layer Content v. Cadastral Layer Compilation Methods

1A Geodetic control base layer/computed cadastral layer Procedurally, what this means is that the person compiling the cadastral layer has a more or less complete map or data set of the locations of geodetic control points (which may be augmented by property corner points which have been surveyed and tied, to a known level of accuracy, to the geodetic control net). In addition, he/she has a complete set of recorded property surveys, plats, assessor maps, and deed descriptions.

The compiler reads the descriptions, identifies points in the geodetic control layer with points in the surveys and descriptions, computes, adjusts, and balances the position of other points on the surveys and descriptions, and enters these points as the location of property corner points in the cadastral layer. The process is slow, as so many sources have to be cross-checked and so many computations done. It can be accurate, if done using correct procedures, there is a high density of known points, and if the property surveys are accurate. If these conditions are not all true, the accuracy of location of points away from the known control points is indeterminate. The resulting data layer is a good framework for most other users of assessor maps to register their data layer, since it contains a large number of the same points as these users keep track of. If the accuracy of location of these points is known, they form reliable locational references. Some users, particularly those who are not presently users of assessor maps, may not have property corner locations in their data layers, and thus be unable to register their layers to the cadastral layer. They may, however, have the locations of geodetic control points and be able to register using those.

1B Planimetric data base layer/computed cadastral layer The cadastral compiler follows essentially the same procedure here as in cell 1A, but instead of a map or data layer containing only geodetic control points (and some property points tied to this net), he/she has a layer or map containing, in addition, structures, road edges, fence lines, sidewalks, power poles, vegetation, hydrology, and so on. Rate of compilation would still be somewhat slow, as each deed description would still be checked and corner locations computed, but the rate would be higher than that obtained in cell 1A as the compiler could see the overall context into which the property descriptions fit. Resolving conflicts -- the most time-consuming part of the cadastral compilation process -- would be particularly expedited. Accuracy of location of cadastral data is highest of all the combinations (of data base layer/compilation method), again because the compiler can see evidence on the planimetric layer. This evidence supplements that of the deed descriptions and surveys, and in addition helps to safeguard against blunders in location decisions. This combination affords the best reference framework for other users, whether they have geodetic points, property points, or planimetric features in their layer to register with.

1C No base layer/computed cadastral layer This combination results in what Kjerne and Dueker [1984] identified as a "cadastral base map". The compilation procedure is similar to that of the previous two combinations, but there is no reference layer of any kind to begin from; the cadastral data is simply compiled to be as self-consistent as possible. In practice, this combination is uncommon in its purest form, since an attempt will be made in almost every case to have some connection to control points located on a common grid. This combination could be regarded as lying on the extreme end of a spectrum, the other end of which is defined by the situation obtaining in cell 1A, which assumes a high density of control points. In situations closer to this end, though, the rate of compilation will become slower (as it becomes more and more difficult to resolve conflicts among deeds and surveys), accuracy will decrease, and the framework for other users to register their data sets will become less useful (although it should be at least minimally helpful to the majority of assessor map users).

2A Geodetic control layer/digitizing assessor maps Under this procedure, the compiler has a geodetic control map or data layer, but instead of computing the location of each property corner, the existing assessor maps are converted to digital form (by using a digitizing tablet or scanner) and fitted to the geodetic layer by "rubber sheeting". This method is rapid and fairly accurate -- at least in comparison to the original maps, which may not be saying much. Discrepancies between the original maps and their form in the cadastral layer will not be resolved, nor will any conflicts among deeds and surveys. As with the combination in cell 1A, this provides a reasonable reference framework for most other users' data sets.

2B Planimetric base/digitized assessor maps This method is identical to that of 2A, except that a planimetric base map or data layer is used to reference the digitized assessor maps. Generally, this method should be a little faster (since there are more possible points to reference the property corners to). Overall accuracy should be higher, again because of the larger number of reference points in the base layer. And, as in the combination of cell 1B, it should present the most broadly useful reference layer combination.

2C No base layer/digitized cadastral layer This method also results in a "cadastral base map". Rate of compilation is high, since all that is done with the assessor maps is that they are digitized and stretched and shrunk to fit each other. Accuracy of location is lowest of all the combinations (unlike method 1C, no checks are made for conflicts among deed descrptions or surveys). This method provides a fair framework for other users to register their data.

None of the methods, as presented above, really addresses the problem of updating locations in the cadastral layer or of capturing the full range of locational interrelationships occuring among cadastral data. All the methods assume that locations of objects in the cadastral layer will be described by reference to the grid origin.

An evaluation of alternatives

Situations unboubtedly exist for which any one of the compilation methods and base layer combinations discussed above would be optimal. Given the goals identified in the first part of this paper, however, neither of the options of column C can be recommended, primarily because they do not address the "accuracy" goals identified for both MPC agencies and assessor map users.

Regarding the other four alternatives in the light of identified goals, it should be noted that the assessor's goal "to develop a procedure with DOR for similar situations" is supported by "to work with DOR in preparing a cadastral layer". When they undertake a mapping project for a county, the Department of Revenue's practice is to reconstruct the assessor maps from basic sources; given the usual condition of the county assessor mapping systems, this is much preferable to simply redrafting (or, in the case of computer-aided mapping, digitizing) the old maps. Thus the choice appears to be between methods 1A and 1B, which differ from each other simply in the type of data in the base to which the cadastral locational data are fitted.

There's a little more involved than that, however. If the <u>description</u> of the location for cadastral data is not captured -- whether or not it can be used to <u>automatically</u> update an object's location -- it would be a waste of effort to reconstruct the cadastral layer, compared to the cost of simply digitizing the maps and "rubber-sheeting" the parcel polygons to a base layer.

We have identified three alternative approaches to the capture of location description data:

The first is to develop a cadastral layer schema which will allow the multipurpose cadastre to automatically update the location of individual cadastral objects when their location rule, reference object(s), or parameter(s) are changed.

The second is to use a conventional cadastral layer schema to store the location of cadastral objects, but to also capture the location rule, reference object(s), and parameter(s) for each object in a separate file, which may be accessed to update locations either manually or by user-written programs.

The third approach is to not capture the decision data.

Now we can consider each of these approaches to decision data capture in combination with the base map content and cadastral layer compilation methods discussed earlier. Rather, we will consider certain of the possible combinations. Logically, some of the conditions or options do not fit with each other. For instance, if location data is gathered by digitization rather than compiling from primary sources, no unique decisions have been made about the locations of specific objects relative to each other -- the rule is the same in each case: apply an offset in the x and y directions to the origin of the grid system. So it doesn't make sense to record such non-unique decision data for each object. And since the option of "no base layer" does not meet the identified accuracy goal for MPC producers or users, that particular set of combinations will also not be examined.

The combinations of a geodetic control base layer *or* planimetric base layer *and* computing the cadastral layer *and* deriving the location data meet most of the goals identified in the earlier part of this report, with the possible exception of the "minimize cost" goal. Developing a cadastral layer schema which can derive location will require a modest research effort on the part of system developers, as this is a problem which has not been attacked before. Cost of such a research effort is an unknown item (although the problem involved is, in principle, readily soluble).

The choice between a geodetic base layer and a planimetric base layer (column "A" and "B", respectively) would be made in terms of drawing a balance between the goals "to minimize overall costs of developing and maintaining a cadastral layer" and "to facilitate inter-agency sharing of geographic data". Overall costs would be minimized if an adequate cadastral base layer were developed. Sharing of geographic data would be maximized if a planimetric base layer were developed.

The combination of a geodetic control base layer *or* planimetric base layer *and* computing the cadastral layer *and* capturing the decision data) would require a certain amount of development effort to devise a separate file schema and method for capturing the cadastral compiler's location descision for each cadastral object, but no research effort in the sense of exploring a novel type of data base schema. These combinations of methods are less able to meet the goals identified earlier, primarily because the "manual" update of cadastral location data (a separate operation from updating the decision, or description, file) would be time-consuming, error-prone, and expensive compared to automatic updating. Development costs would be lower, but operational costs higher, than the previous pair of options.

A non-base layer data schema

Figure 1 (next page) portrays a schema [adapted from Van Demark, 1985] of three layers of a computer-aided cadastral mapping system which allows derivation of the locations of objects in a non-base cadastral layer from their spatial relations to other objects which may be in other layers.

Topological relationships are handled with corner, boundary, and parcel tables and two tables giving the relationships between parcels and boundaries, and parcels and property corners.

Location for cadastral objects is handled by two tables, one for corners and one for boundaries. These treat location as an attribute. A point is located using one rule, one or more reference objects, and zero or more parameters, each of which may be recorded as a data item in a relational table. The rule (which is referenced in a rules table) duplicates the decision of the cadastral cartographer in defining the location (in the case of a property corner) or shape (in the case of a boundary) of the object when he or she analyzed the parcel description.

Thus, for instance, a Corner defined to be at a survey monument would be located by a Rule which stated, in effect, "use the x,y,z coordinates of the Monument, located in the Survey layer, as the coordinates for this Corner."

A Corner with a location defined as being at the intersection of a surveyed line and a right-of-way would be displayed (or its coordinates derived) by:

- finding the survey line in the Survey layer
- finding the right-of-way line in the Right-of-way layer
- computing the intersection of the two lines

A Corner location might be defined in a deed description as being "at the intersection of a line parallel to, and 100 feet southerly along the westerly line of Smith's parcel, the northerly line of Jones' parcel, and the centerline of Crawdad Creek". Again, the Corner record would contain a reference to a rule in the Rule table directing the location routine to:

- find the "westerly line of Smith" in the Boundary file
- find the "northerly line of Jones" in the Boundary file
- find the "centerline of Crawdad Creek" in the Survey Lines file (if the creek has been surveyed) or in the Planimetry layer (if not)
- compute a point 100 feet southerly along the "westerly line of Smith"
- compute the intersection of a line parallel to "northerly line of Jones" and passing through the point on Smith's line, with the "centerline of Crawdad Creek"
- return the x, y, (and perhaps z) coordinates

The Boundary Shape rules, in the Boundary table, perform an analogous function to the Corner location rules, operating on two or more reference objects in the Boundary Reference Object file and on zero or more parameters in the Boundary Shape Parameter file. Most boundaries are straight lines between property corners, so the rule would be straightforward. On the other hand, some boundaries are simple curves, or are defined as being coincident with right-of-way spirals, or as being "parallel to and 100 feet distant from" a stream edge. As with the property corner definition of location, the rule used to define the location of a boundary shape duplicates the decision made by the cadastral cartographer in analyzing the property description.

The structure of the locational data for layers referred to by the cadastral layer (in the examples presented, the recorded survey layer) is the same as for the cadastral layer, allowing location to be recursively derived from the location of objects in the base layer.

In addition to the topological and location and shape tables presented for the cadastral layer, other tables are defined to handle groupings of objects (parcels into map groups, boundaries into parcels), names (annotation), and attribute information.

Conclusion

In this paper, we have presented the choices available to agencies building a multipurpose cadastre in terms of methods of constructing a cadastral layer; content of the base layer; and approaches to capture of the description of spatial relationships among objects in non-base layers. The choices made among these by the agencies resposible for the multipurpose cadastre must be made on the basis of their goals for it.

Thus, for instance, having accuracy of location as a relatively important goal would indicate computing cadastral locations from deed and survey data as the method of choice for constructing the cadastral layer. Computation from these primary sources would reveal, and resolve, many of the existing ambiguities and conflicts among neighboring parcels. If, on the other hand, keeping initial costs low and rapidly producing a cadastral layer are seen as more important, then digitizing existing assessor maps without recomputing would be sufficient.

Any multipurpose geographic information system must be based on a reference system common to all its users. For a multipurpose cadastre, this would be a reference layer of geodetic control points. Whether there will also be a layer of planimetric data will again be dependent on the goals held by the agencies involved in building and using the multipurpose cadastre. Having a planimetric layer would facilitate both construction and maintenance of other layers of data, including the cadastral layer. Such a layer, constructed to a specified standard of accuracy, would provide a framework for other layers with a large number of relatively accurate reference objects. This densification of objects in the refererence layer would in turn facilitate updating of non-base layers. A layer of planimetric data would facilitate sharing of geographic data among users. It would also be relatively costly to produce.

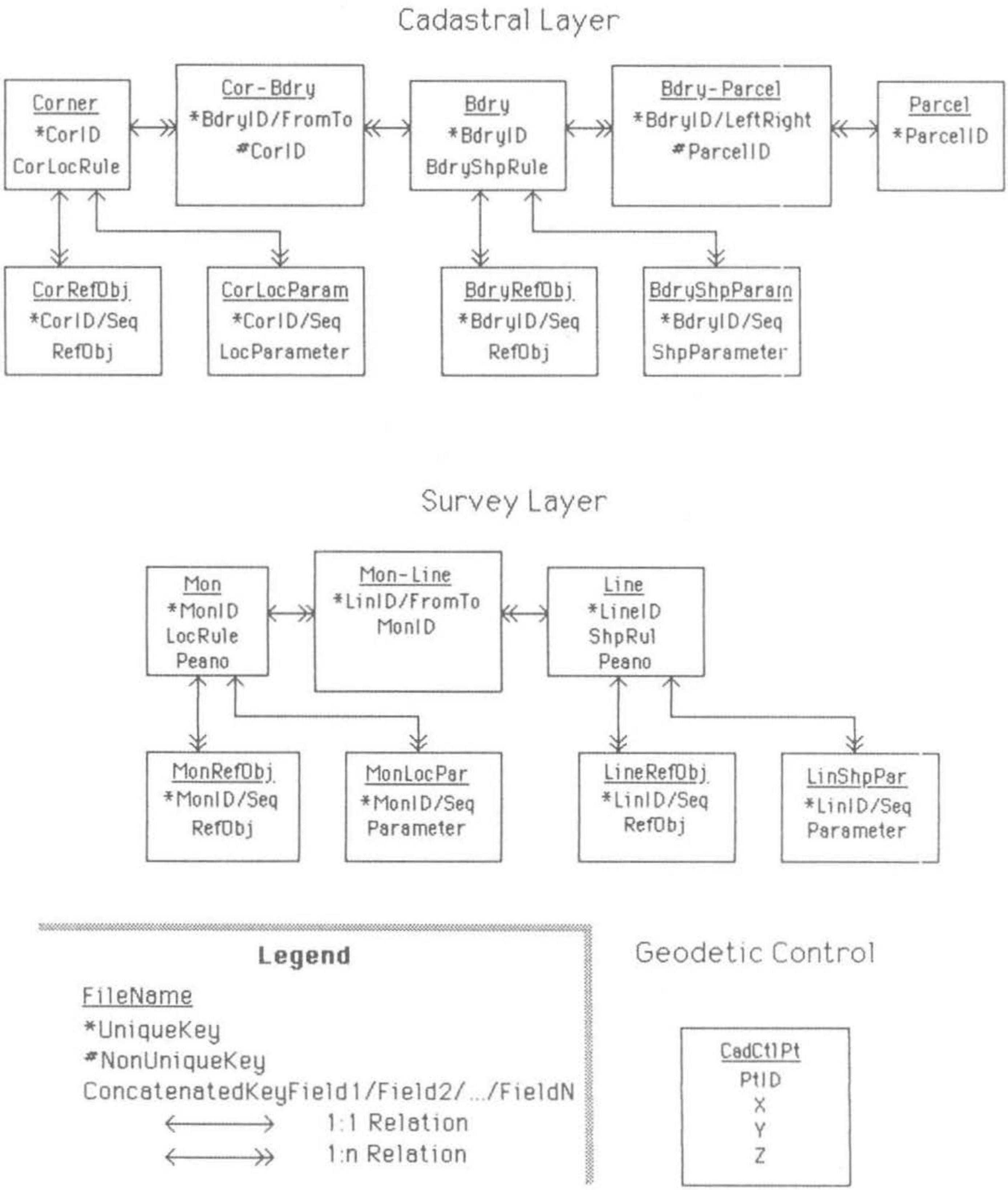
After a map is created, it must be updated if accuracy of locational and non-locational data is to be preserved over time. Updating the locations of property corners and the shapes of boundaries is a particularly challenging task, compared to other types of data, because of the wide variety of rules and interrelationships occuring among cadastral objects. If it is held as a goal that the cadastral data be accurate and timely through the whole area mapped, then updating has to be a continuous process. This means that the essence of each parcel description must somehow be captured in such a way that an algorithm can follow it, deriving the locations of objects in their correct present locations. Unfortunately, this issue has not received much attention by designers of multipurpose cadastres. In this paper, we have presented a data structure that should allow such capture and update, but it is, as yet, an untried concept. Thus, an agency wishing to implement the goal of having a continuously updated multipurpose cadastre would be in conflict with a goal of using only tested and readily available technology.

As we indicated above, the crux of the matter in choosing among the compilation methods, base layer contents, and data capture approaches, is to identify the goals held by the agencies involved. This should include the present users of assessor maps as well as the present producer of assessor maps (it would be nice to include possible future users of a multipurpose cadastre, as well). The problem, of course, is that all of the various goals mentioned will be held by some of the actors involved: one user desires higher accuracy, all wish for stability in cost, most want more data types and flexibility of presentation, etc. Our efforts to identify and clarify the issues involved in constructing and updating a multipurpose cadastre should aid the assessor and other County agencies to balance the various goals and implement a successful multipurpose cadastre.

Figure 1.

A Data Schema Which Allows Derivation of Location and Shapes of Objects in Non-Base Layers

[After Van Demark, 1985]



REFERENCES

American Society of Photogrammetry (The Committee for Specifications and Standards, Professional Practice Division). February 1985. "Accuracy Specifications for Large-Scale Line Maps". *Photogrammetric Engineering and Remote Sensing*, vol. 51, no. 2, pp. 195-199.

Crisman, N.R., and Niemann, B.J. 1985. "Alternative Routes to a Multipurpose Cadastre; Merging Institutional and Technical Reasoning". *Technical Papers, 45th Annual Meeting, ACSM.* American Congress on Surveying and Mapping, Falls Church, VA.

Harvey, R.B. 1985. "The Use of Orthophotography and GIS Technology to Conduct a Storm Drainage Utility Impervious Surface Analysis: A Case Study". *Technical Papers, 45th Annual Meeting, ACSM.* American Congress on Surveying and Mapping, Falls Church, VA.

Kjerne, D., and K. J. Dueker. "Two Approaches to Building the Base Layer for a Computer Assisted Land Records System". *The Changing Role of Computers in Public Agencies* (Papers from the annual conference of the Urban and Regional Information Systems Association, August 12 -15, 1984), Urban and Regional Information Systems Association, MacLean, VA.

Van Demark, P. March, 1985. "A Model Schema for Geographic Base Layer". Survey sent to Spatial Oriented Reference System Association (SORSA) members.