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User Needs Assessment and Technical Issues for a Multipurpose Cadastre for Multnomah County, Oregon

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Chapter 0

INTRODUCTION

Objectives of this study

The objectives of this study are: 1) to provide the County Assessor with a survey of the current usage of the assessor's mapping system; 2) to assess the future data needs of the users based upon implementation of the assessor's plans for a computerized cadastral mapping system, or **multipurpose cadastre (MPC)**; 3) to identify the locational accuracy requirements of the proposed mapping system; and 4) to identify a strategy to facilitate gradual improvement in accuracy of locational data.

Structure of this report

This report is divided into two major sections, plus an introduction and appendices. The remainder of this introduction defines some of the terms used, gives some background information on the assessor's mapping system in Multnomah County, and discusses MPC goals as they were identified at the outset of the project by the clients and investigators.

The first section (chapters 1, 2, and 3) forms the Users' Needs Assessment. In chapter 1, we present a picture of how users relate to the present assessor's map system, with a typology of users and an analysis of scale, content, format, and update needs for each category of user. Chapter 2 discusses how each category of users sees its needs and resources as participants in a land information system with a multipurpose cadastre as its core. Part of this chapter is a compendium of "wish lists" for each user category, and is an illuminating view of the types of data users would like to have access to in the best of all possible worlds. Chapter 3 is an attempt to identify goals assessor's map users have for an MPC, and to compare those goals to those identified, in the Introduction, for the assessor's office.

The second section of the report discusses some design considerations and technical requirements implicit in the goals identified in the first part. In chapter 4, we present a conceptual model of a land information system with a multipurpose cadastre, as well as a series of questions which such a system must be capable af answering in order to be considered workable. Chapter 5 discusses different approaches to compilation of a layer of cadastral data. Chapter 6 details some of the considerations to be allowed for in building a land information system to handle engineering survey, property survey, and geodetic control data. Chapter 7 presents a series of recommendations based on the goals and considerations discussed above.

The appendices essentially present further data which wouldn't fit gracefully in the narrative part of the report. They include a list of organizations contacted for the user needs assessment, a report on the status and availability of geodetic control and large-scale mapping data in Multnomah County, and other similar items.

Definitions of terms

The Multnomah County Assessor is responsible for maintaining a county-wide mapping and record system to support the assessment of real property and the collection of property taxes levied by jurisdictions in the County. This is sometimes called a cadastre.

Derived from a Greek word meaning "line-by-line" as in a notebook, the **cadastre** is a record of the status of each piece, or parcel, of land in the territory as regards ownership, taxation, quality, size, use, or whatever other attribute may be of interest to the compilers. The **cadastral mapping system**, derived from these records and others describing the location and shape of the land parcels, serves as an adjunct to the cadastre to aid administrators and property owners in using records.

There are, in general, two broad classes of use for land parcel records. The cadastral maps and the records used in conjunction with them to assess the value and tax status of land fall under the class of administrative use. Hence, these records and maps are sometimes called an **administrative cadastre** (although strictly speaking this term applies only to the written records, not to the maps). In most counties the administrative cadastral map system is the only county-wide parcel level mapping in existence.

Another set of records, which pertains to the legal description and the type of rights in the land, forms the **legal** or **juridical cadastre**. The two sets of records are often used in close conjunction, and are often lumped in the same category. It is important to note, however, that the administrative cadastre and the cadastral maps are not themselves legal documents as regards the description of land. They represent the effort by assessors to find a tool to fairly and equitably carry out their function, and as such represent an attempt to discover and to correctly represent the true status of rights in land; but legality is reserved to the deeds and other instruments recorded in the juridical cadastre and referred to by the administrative cadastral system. Together, the juridical and administrative cadastral systems serve many users of land records.

The term **multipurpose cadastre (MPC)** has gained currency in recent years as assessors and others involved in land records have sought to emphasize the need to link more closely the various kinds of land records, with the goal of increasing the utility, accuracy, and availability of parcel related data to their various users. Often, this has occured in the context of applying **geographic information system (GIS)** technology to the problems of cadastral mapping. A 1983 report of the National Research Council linked GISs and multipurpose cadastres in this way:

> ...A GIS is any system of spatially referenced information or data. Spatially referenced information or data have a unifying characteristic--association with a specific place on the Earth's surface. A GIS is designed to gather, process, and provide a wide variety of geographically referenced information that may be relevant for research, management decisions, or administrative processes...
>
> A multipurpose cadastre is designed to record, store, and provide not only land-tenure and land-valuation information but also a wide variety of parcel-relatable information. It is truly multipurpose in that it not only receives information and data from many sources, but it also provides relatable services and products for many purposes and to many users.
>
> The multipurpose cadastre is the core module of a large-scale, community-oriented information system designed to serve both public and private agencies, and individual citizens, by 1) employing the proprietary land unit (cadastral parcel) as the fundamental unit of spatial organization, and 2) employing local government land-record offices as the fundamental unit for information dissemination. [NRC, 1983]

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 challenges to this technology. Perhaps the most intriguing problem of cadastral mapping is that of handling locational data -- the data which, ultimately, determines where objects such as property corners and rights of way will be found. One way to appreciate this problem is to consider the current process of updating assessor's maps.

When an assesor's 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 State Department of Revenue (DOR) under its authority to provide uniformity in assessment and taxation. The Records Management Division of the 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 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) locational data being inaccurately portrayed. Some of the old, unreconstructed maps presently used by the assessor's office were originally drafted fifty years ago, and the basic framework to which new surveys are added is quite inaccurate by present-day standards.

Geographic information system technology holds out a number of promises, one of which is particularly relevant to the problem outlined here: a computerized multipurpose cadastre should (if properly set up) be able to continuously reconstruct the location of cadastral objects, based on the most accurate available data. Thus, once cadastral maps were converted to digital format, one should be able to view a map of parcels or enquire the size and shape of one or more parcels knowing that one was looking at the current situation, not one based on months-old or decades-old measurements.

Identified goals for a multipurpose cadastre

In December of 1984, officials of the Multnomah County Assessor's Department and the Multnomah 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 on assessor maps**
- **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 identify some of the assumptions and preliminary tasks implied. The following discussion summarizes the main points brought out at that time:

What does the goal **to eliminate title problems on assessor maps** mean, and how could moving to a computer-aided multipurpose cadastre help accomplish this?

Title problems on assessor maps can show up as uncertainty about the ownership of a parcel where the location (with respect to neighbors) is not in question; uncertainty about location of a parcel (with respect to neighbors) where the ownership is not at issue; or some combination of the two. It may be, in the process of DOR's reconstructing the cadastral layer in order to convert the map data to digital format, that some of the difficulties of the first kind will be resolved, since the preliminary steps involve researching the deed record and at least partially reconstructing the chain of title. The main impact of a computerized cadastral map layer would, however, be in an improvement in the accuracy of property boundaries as a result of improved linkage to property surveys. 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 in which less-accurate measurements are fitted to more accurate ones rather than the reverse.

The goals **to minimize overall costs of developing and maintaining a multipurpose cadastre** and **to develop a system or procedural model usable by DOR in other similar situations** were both supported by a single lower-level goal, identified as **to work with DOR to produce a cadastral layer**.

It was argued that overall costs would be minimized if each agency -- the Multnomah County Assessor and the State Department of Revenue -- concentrates its resources and expertise on one area of system implementation: the DOR on development of the cadastral layer (in which they have had a number of years of experience) and the County Assessor on maintenance. From the DOR's point of view, it would be possible to achieve certain economies of scale, since they plan to upgrade their present computerized mapping system. This upgraded system can then be used to produce a number of cadastral data bases for other counties in Oregon. The system could be specialized, oriented toward production rather than toward information update, specialized output products, and linkage with other information systems. The assessor's office sees itself best suited to concentrating on the maintenance of the multipurpose cadastre and gradually expanding the flow of data communication among other participants in a land-information system. This course of action requires a smaller initial investment and a more gradual entry to the realm of computerized mapping. This latter point is an important one in the context of institutional dynamics: too often, the sudden arrival of a new "total system" has created confusion, disorganization, and loss of morale.

A computer-aided cadastral mapping system would support the goal **to facilitate inter-agency sharing of geographic information** by providing a uniform base map usable by other agencies on which to register their layer of geographic information. A computer-aided mapping system can rapidly produce maps of the same content but various scales and formats. Thus, for instance, a planning agency which did not itself have a computer mapping capability could request a map from the cadastral mapping agency showing parcel boundaries, street addresses, and rights of way made to the same scale as planning maps. After placing their map in register with the parcel map, the planners could edit their map (for instance, to make planning unit boundaries coincide with property boundaries) and prepare a file linking parcel addresses with the land-use planning zones. An agency <u>with</u> computer mapping capability would be able to do the same type of thing using a digital image or file of geographic data rather than a paper map. In addition, such an agency could prepare maps or reports combining digital geographic data from other agencies -- if a common reference system existed.

During January, February, and March of 1985, the project staff conducted some 40 interviews of public and private organizations using Multnomah County assessor's maps. (A list of orgainizations contacted and the questions asked appears in Appendix A.) Our goals during this phase of the investigation were to find out what kind of data users currently draw from assessor's maps and what kind of expectations they have of a computer-aided cadastral mapping system, or multipurpose cadastre. We were also interested in how users visualized their own involvement with a land information system, with each participating agency having a greater or lesser level of computer-aided mapping capability. The summary of these interviews forms the next part of this report.

Section One

User Needs Assessment

Chapter 1

ASSESSOR MAP USERS AND THE PRESENT MAP SYSTEM

A typology of assessor's map users

The assessor's map system is, at present, the only available parcel-specific, county-wide base map. As a result it attracts many different individual and organizational users. The most frequent users can be divided into four groups: Title Companies, Facilities Management and Construction, Planning and General Governmental Administration, and Public Safety. As portrayed in Table 1, each group has different needs described in terms of their functional map use, accuracy requirements, geographic coverage requirements, and frequency of map updates.

USER TYPE	GEOGRAPHIC COVERAGE	ACCURACY REQUIREMENT	UPDATE FREQUENCY
Title Insurance Company	Tri-County	Not stated	Continuous
Facilities Management and Construction			
Private Utility	More than Tri-County	Varies, ±1 ft to ±10 ft	Annually to Monthly
Public Utility & Transportation	Sub-County to more than Tri-County	±1 ft	Continuous to Monthly
Engineering, Surveying, & Photogrammetry	Tri-County to more than Tri-County	±1 ft	Continuous to Monthly
Planning and General Admin	Sub-County to County	Varies, ±1 ft to ±100 ft	Continuous to Monthly
Public Safety	Sub-County	±100 ft	Continuous

Table 1. A Typology of Assessor's Map Users

A note on users' perception of map accuracy requirements

The issue of mapping accuracy arises at several junctures in the present report. The acceptable level of map accuracy in each case is directly related to the scale of the map involved. For instance, a locational error of ±1 foot on a map at the scale of 1 inch =100 feet is considered to be acceptable by most map users. It is not acceptable if the scale is 1 inch =10 feet and is not noticeable if the scale is 1 inch = 1000 feet.

Accuracy, for most map users, relates to the degree of confidence that a measurement made on a map will correspond to a measurement on the ground. It is not always clear whether the stated need for accuracy reflects an anticipated future need or a current need. Accordingly, accuracy needs listed in this section are assumed to exist currently and to remain constant for any future system. There are some users (primarily engineers and surveyors) who expressed their accuracy needs both in terms of ground location accuracy and more technical standards. The most commonly mentioned were the National Map Accuracy Standards and the standards set for the State Plane Coordinate System. Accuracy is also discussed in terms of representative fractions such as 1 part error in 10,000. Although these approaches are different in their level of detail, they are similar enough in their implied requirements for the production of a new computerized mapping system that they need not be considered separately. It should be kept in mind when reading this report that these different ways of expressing map accuracy requirements do exist.

Title Companies

Title companies use both graphic and nongraphic data supplied by the Courts, County Assessor, and County Recorder as the base for granting title insurance. This insurance guarantees that the purchaser of property is acquiring title to the property as described, subject to the deed restrictions listed in the title report. The assessor's maps are used in this system both as a graphic index of lots and as a base map supplied for informational purposes to customers of the title company. All parcels shown on assessor maps are identified by the title companies by an ARB number (arbitrary number). This number differs from the assessor's tax account number. The ARB number never changes for a piece of property and is the basis for establishing a chain of title. This number is used to locate records (recorded documents) kept in a company's title plant. A tax account number on the other hand can change when, for example, a 1/4 Section map is redrafted as a 1/16 Section map.

Three title plants are currently being maintained in the tri-county area by the large title companies. These title plants each cover Multnomah, Clackamas, and Washington Counties in their entirety. This is indicative of the fact that title companies segregate their operational areas by county or by a group of highly interconnected counties such as exists in the tri-county area. Safeco Title and Ticor Title currently operate independent title plants (i.e., they maintain all of their own records, duplicating each other). The other five large companies, Stewart Title, Transamerica Title, First America Title, Lawyers Title, and Chicago Title, use a central computerized title plant established in 1980 and currently maintained by First America Title. These companies still maintain their existing individual title plants for all records and deeds recorded before 1980. The computerized title plant uses software developed in the early 1970's and is relatively old. The software company that has been maintaining the system has given notice that it will soon stop providing support for the old system. This problem might be solved by Stewart Title. Its subsidiary, Landata, has taken over support for this same software system in other parts of the country.

Stewart Title is unique in the title insurance industry, providing services beyond those normally delivered by a title insurance company through its two subsidiaries, UAM, Inc., and Landata. These two companies have developed computerized assessor mapping and record keeping systems, starting with a planimetric base map. These systems have been used in several counties in Texas, including Harris County (Houston). Appendix B contains information descriptive of UAM and Landata.

Update, Accuracy, and Scale Requirements

The 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 inch = 100 foot scale is preferred by the title companies because of readablitiy and familiarity. Accuracy is not a major issue with the title companies. The maps they provide are considered to be a representation, not necessarily to scale, of the situation and are for general locational purposes only.

Current Uses of Assessor Maps

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 map systems 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

Facilities Management and Construction

Facilities Management and Construction users are the largest group of users of assessor maps in the County. It is possible to break this group into three subgroups that have slightly different uses for maps and long term information needs. However, they should be considered as subsets of a single group rather than individual categories of users. These subgroups are: 1) private utilities; 2) public utilities and transportation; and 3) private engineering, surveying, and photogrammetry firms. Both public and private utilities have facilities--lines, poles, manholes--to manage. Some are interested in the general location of their facilities within ±10 feet to ±1 foot. Construction uses require accuracy on the order of ±1 foot to ± 0.1 foot.

PRIVATE UTILITIES

Private utilities using assessor maps provide electricity, telephone and natural gas service to Multnomah County residents. These companies all have extensive distribution systems and are among the largest property taxpayers in the state. Accordingly, they have a strong interest in the management of their physical facilities and in accurate assessment of their property holdings.

These companies have made commitments to computerize their own mapping systems to improve their facilities management. Northwest Natural Gas Company has been using computer mapping for the longest time. Its current system is a relatively old computer assisted design (CAD) system purchased in 1976 and upgraded in the late 1970's. The product of this system is a schematic map of the Gas Company's facilities that varies in its accuracy from area to area. (The process of digitizing existing assessor maps required that each 1/4 section be made into a perfect square to fit within the operational parameters of the CAD system). The gas company expects to replace its current system with a newer one in the next 2 to 4 years.

Portland General Electric has a newer Intergraph computer assisted mapping (CAM) system. The construction of a digital base for this system presented PGE with some problems. Digitizing the assessor maps to fit into this system has required about four staff hours for each quarter-section map. The resulting base map layer has varying degrees of accuracy across map area layers. PGE's primary concern was to put their distribution facilities onto the system, rather than to digitize an accurate base from assessor maps. The estimated accuracy level within the system is ±10 feet.

Pacific Power and Light Company has just started to computerize its mapping system. They have purchased a CAM system from Synercom and are beginning the work of developing a digital base map in the Medford area. They expect that it will be a few years before they are ready to start in the Portland area. Pacific Northwest Bell is just now preparing to computerize their mapping system following an internal study of the benefits of computer mapping.

All of these companies are currently using or establishing computer mapping systems. They could potentially benefit from the establishment of a computerized assessor mapping system in large part because of its expected accuracy levels. But this would require some commitment of resources from these companies in order to adapt their existing data bases to the new assessor maps. There is no way to estimate at this time whether or not it would be beneficial (from a cost standpoint) for these companies to change their existing or growing systems. PGE has indicated that at this time it would not be interested in converting its existing system so that it could use the projected county computerized base map.

Update, Accuracy, and Scale Requirements

As previously noted, two of the companies, PGE and Northwest Natural Gas, 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 inch = 100 feet for most uses. They prefer that the level of map accuracy be somewhere between ±1 foot and ±10 feet depending upon actual map use.

Current Uses of Assessor Maps

Assessor maps are commonly used to keep track of property tax payments, 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 Codes
Property Corners	

PUBLIC UTILITIES AND TRANSPORTATION

Public Utilities and Transportation users constitute the largest number of public agencies using the assessor mapping system. These agencies or departments are responsible for constructing and maintaining sewer, water, storm drainage, street and highway systems, right of way acquisition, and public transit systems. This category includes city departments in Portland, Gresham, Troutdale, Fairview, and Wood Village; Multnomah County departments; the State Highway Division; Tri-Met; the Port of Portland; Rockwood Water District; and Bonneville Power Administration. These agencies are involved in the costly process of developing and maintaining public infrastructure in Multnomah County.

For most of these agencies the assessor maps are the only county wide or jurisdiction wide base map available at a parcel level. In the case of the City of Portland, its Department of Transportation has taken on the construction of a new set of base maps for the City. These maps are constructed from known survey data in the same fashion that the County Assessor formerly reconstructed the base maps for the assessor mapping system and in a similar fashion to that used by the State Department of Revenue. The City has constructed a significant number of these maps. Most of west Portland and the industrial lands surrounding Delta Park and Portland International Airport have been remapped using this system. The coverage of East Portland is currently rather sparse. The City has constructed a series of overlays containing data on the location of streets (as traveled), storm drainage facilities, sewer lines, water lines, curbs and sidewalks.

The City of Troutdale had a new set of planimetric base maps produced in 1983 using an aerial photo base. This system functions as a base map showing physical features and contours at 2 foot intervals. The City currently relies on this base map, rather than the assessor maps, for most of its work in facility planning and maintenance.

The State Highway Department, Tri-Met Light Rail Transit project, Rockwood Water District, and Multnomah County Department of Environmental Services begin the construction of their project maps with data derived from the assessor's maps. This includes lot lines and street right-of-way information. At times, these maps are used as base maps for preliminary engineering and the discussion of general design alternatives.

In addition to the engineering design and facilities maintenance work done by these agencies, land surveying work is also undertaken by the surveyors for the Port of Portland, Bonneville Power Administration, Tri-Met, City of Portland, Multnomah County, and the State Highway Department. Their needs are very similar to the private surveyors discussed in the next section. Surveyors use the maps as an index system. The maps themselves are not accurate enough for surveying but can provide valuable reference information in the form of map notes or items such as street vacation ordinances and county road numbers. Surveyors generally prefer to map at a scale of 1 inch = 50 feet, or 1 inch = 20 feet in the more highly developed areas.

Many users obtain their information from the microfilm copies distributed by the City of Portland to more than 60 recipients. These microfilm sheets contain the following maps on a quarter-section basis: the Assessor Map, a Zoning Map drafted on the assessor maps, and the Portland quarter-section base maps containing the location of sewers, streets, storm drains, and water lines. This system is as close to a multiple set of layers of data at the same scale as is currently available.

Many of these agencies have a need to review data on a more generalized system-wide basis. The assessor's other set of maps (1 inch = 600 feet) is used by many agencies for constructing these maps. At this level it is possible to consider larger pieces of a physical system such as a water system or a street system in a large portion of a city. The Port and Tri-Met use these maps for an inventory of their project sites and holdings. Other jurisdictions also make use of this scale.

Scale, Accuracy, and Update Requirements

Users of assessor maps within this category 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 inch = 100 feet. It is often necessary, however, for them to work at 1 inch = 50 feet or 1 inch = 20 feet 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.

Current Uses of Assessor's Maps

All agencies and departments included in this section 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

PRIVATE ENGINEERING, SURVEYING, AND PHOTOGRAMMETRY

Private engineering and surveying firms use assessor maps as a starting point for construction and land development projects, public or private. This user group is most directly concerned with the ongoing modification and construction of the physical environment of the County. Engineers and surveyors use the assessor maps in slightly different fashions. Private Engineering firms often use assessor maps as a base for preliminary engineering (PE) work. These are used to estimate the workability of a particular proposal. Once the PE is done it is usually necessary to have a site surveyed in order to produce final engineering drawings. At this point the accuracy demands of a project exceed the level assessor maps are currently able to attain. Surveyors use the assessor maps as an index or starting point to locate all previous survey work and establish beginning points. Surveyors and engineers also have different accuracy requirements. Engineers need accuracy at ± 1 foot for PE, generally relying on assessor maps and any other data available. However, assessor maps do not achieve the accuracy required by surveyors. In addition, the maps do not portray the data needed by surveyors to actually locate survey monuments on the ground.

Photogrammetrists do not currently make use of the assessor's map system. The primary product of their work is planimetric and topographic maps drawn on or from airphoto coverage of an area. However, they do use assessor maps for index purposes and sometimes attempt to add property lines to the planimetric layer. They would also be the producers of the planimetric layer of data essential to a multipurpose cadastre and, as such, are potential users of the system. Local photogrammetrists are active in the American Congress on Surveying and Mapping (ACSM) effort to establish national mapping and multipurpose cadastre standards. They are vitally interested in progress of the proposed MPC and the topographic and planimetric layer included in such a system.

Update, Accuracy, and Scale Requirements

All users in this category 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 inch = 100 foot. They often need to work at 1 inch = 50 feet or 1 inch = 20 feet 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].

Current Uses of Assessor's Maps

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 Government Administration

This group represents a wide range of interests. Planning departments in Portland, Gresham and Multnomah County are the largest users of assessor information in this category. Other users include the Portland Parks Bureau, City Auditor, Portland Public Schools, County Elections Department, Metro, and Tri-Met.

All official copies of adopted comprehensive plan maps, zoning maps, or development code maps are drawn either directly on assessor maps or on maps constructed from assessor maps. These maps form the legal description of the various administrative districts that the planners work from in daily planning efforts. In addition, planners use revised assessor maps to locate newly created lots and to check whether approval has been given for the land divisions shown on assessor maps. It is important that planners have an historical set of records available to consult for the creation of specific parcels of land. (This historical record is important to other facilities management agencies as well). Administrative planners commonly maintain a set of records of previous departmental actions on a set of maps that act as an index of previous decisions.

Long Range Planners also make extensive use of assessor maps. These maps serve as the base map for all new planning maps. These maps can include land areas from a single parcel to an entire jurisdiction (city or county). Long Range Planners commonly map the locations of existing land uses, types of structures, census tracts, census data, areas of service provision (i.e. sewer, water, storm drainage and streets), historic sites, soil types, hazard areas, traffic flows and other general information that may be needed for a particular project. This data serves as input to the process of forming long range plans for the city or county.

The Multnomah County Planning Department, using a grant from the Land Conservation and Development Commission (LCDC), is currently establishing a parcel level land use information system for the unincorporated areas of the County. This nongraphic system will be linked to existing Assessor records in A & T File 14. The file will contain data on land use, administrative actions taken, jurisdictional boundaries, parcel dimensions, addresses, land values, zoning, and a variety of other items. A complete list of the data elements in this file is located in Appendix C to this report. The cities of Portland, Gresham and Troutdale are also considering using this system.

The Multnomah County Elections Department makes use of the 1 inch = 600 foot assessor map series as the base for precinct maps. This permits election mapping of the entire county using only 25 maps. The multiplicity of Multnomah County jurisdictions with elections at different times in different combinations requires the Elections Department to maintain a series of sub-precinct boundaries reflecting overlapping jurisdictions within each precinct. The Elections Department has an ongoing need for data on current jurisdictional boundaries for all jurisdictions within the County. Under their current system, it is relatively easy to map out city boundaries but more difficult for other jurisdictions.

The City of Portland Auditor uses assessor maps for locating property owners that must be notified of pending public hearings. This task is closely related to the work of the Planning Bureau and other City boards and commissions. In other jurisdictions this function is accomplished within the Planning Department.

The Portland Parks Bureau makes use of assessor maps as base maps in some planning efforts, e.g., the development of a series of parcel maps in conjunction with planning the route of the proposed 40 mile bicycle loop. In addition, assessor maps are used as a starting point in the process of reviewing proposed dedications of park lands to the City and in the review of opportunities for future land purchases. The Bureau maps its own parks.

METRO and Tri-Met use the same series of base maps for most public presentations and publications. These are 1 inch = 2000 foot and 1 inch = 4000 foot street maps of the tri-county area. The maps were developed from a state highway base map. They are updated using assessor maps to locate new streets. METRO uses these maps as a base for most of its regional mapping efforts.

The Portland School District makes some use of the assessor maps, primarily in settling boundary disputes over what pieces of property belong in the school district. The District does use computer mapping extensively in its planning of attendence boundaries and bus routes. The base map used for this system is a modified DIME file map.

Scale, Accuracy, and Update Requirements

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 inch = 100 feet 1/4 Section base 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's 1 inch = 2000 feet and 1 inch = 4000 feet. 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 inch = 100 feet and ±100 feet at 1 inch = 2000 feet.

Current Uses of Assessor's Maps

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

Public Safety users (Police, Fire and Emergency Dispatch) make little direct use of assessor maps. Indirect use, as a source of data for dispatch map updates, in internal facilities planning, and in filling general government functions, is extensive. The Portland Bureau of Emergency Communications operates a computer-aided dispatch service for police and emergency medical services (EMS) for Portland, Gresham, and Troutdale, and Gresham fire service. In addition, it is the 911 center for Multnomah County. This means that in addition to police and EMS calls the Center receives all fire calls, passing them on to the Portland Fire Dispatch Office.

The Bureau uses the Census DIME file map as the basis for its dispatch system. This is represented in the computer as a series of street links and intersection nodes that are connected to street addresses. The dispatching is done to a set of cross streets pulled from this map using the address of an incident. This map is updated by hand using assessor maps as source documents.

The other major dispatch system in the County is that of the Portland Fire Bureau. This manual dispatch system uses a series of map books constructed from a 1 inch = 700 feet base map and a series of dispatch books. The starting point for this mapping system is the State Highway Department's 1 inch = 2000 foot road network map. This map is photographically enlarged and then modified to meet the needs of the dispatcher and engine companies.

There may be some changes in these two systems in the next few years. First, the computer system used by the Bureau of Emergency Communications is ten years old. The computer model is no longer manufactured and parts are difficult to find. In addition, this system has had a relatively high operations maintenance cost. Consequently, the Bureau has issued an RFP for a replacement. Proposals were to have been reviewed during April and May, 1985.

The Fire Bureau is also studying the possiblity of moving its operation to the Kelly Butte Dispatch Center. This study is in the early stages and no firm decision is expected until after a decision is made on replacing the existing computer system at Kelly Butte.

The Fire Bureau is one of the agencies responsible for passing on building permits and partitions, since they need to determine whether a proposed building or new lot is adequately accessible by emergency vehicles, and so forth. In this process, they make use of assessor maps to locate the parcel involved and to determine size, situation, and neighbors. Other data, such as hydrant location, is drawn from other maps which were based on the assessor maps.

The Portland Police Bureau and the County Sheriff keep some records on the geographic incidence of crime. These record keeping systems work from a set of arbitrarily established police reporting districts. In the case of Portland, they are tied to the DIME File system, while Multnomah County uses a manual system. These systems have varied over the years as different individuals have been in charge of them.

Current Uses of Assessor's Maps

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	

Chapter 2

THE LAND INFORMATION SYSTEM AND USERS' DATA NEEDS

This chapter summarizes the types of data that different groups of users say are needed in order to make the land information system based on an MPC usable for their purposes. It should be noted that many of these needs overlap. In addition, a rigorous definition of the content of data types has not been made. For instance, planimetry is an omnibus term, the meaning of which was not explicitly determined for each user. It generally includes building locations and outlines; vegetation; street curb, sidewalk, and fence lines; and, doubtless much other information. In general, it is all that data shown on a topographic map which does not relate to elevation.

A group specifying a need for a particular type of data would still find the system usable even if all requested data types were not established as part of a land information system. Most users have data needs they could forego while still benefitting from the overall system. The following can be viewed as an unconstrained listing of data types desired by users.

Title Companies

For title companies, two levels of data needs could be met by an LIS. The first level is essentially the data currently available on existing assessor base maps and which meets most current mapping needs. Some divisions (i.e. subdivision or development sections) within the title companies would benefit from the availability of additional data identifying property suitable for development. The title companies interviewed generally felt they have little to contribute to the process of creating a MPC but they would make use of it. Interviewees indicated a need for the following data types:

ARB Numbers	Parcel Level Base Map
DLC Corners	Sewers
Easements	Streets as traveled
Flood Plains	Topography
Historic Record of Lot Creation	Vacant Land
LID Districts	Water Lines
Natural Gas	Zoning

Facilities Management and Construction

In general, the users of assessor maps in the Facilities Management and Construction category perceived the process of establishing an LIS as being potentially beneficial in most areas of operation.

PRIVATE UTILITIES

Private utilities viewed the proposed multipurpose cadastre project with mixed feelings. Those utilities least interested in it had already made the greatest committment to establishing and maintaining their own computer mapping systems. The companies just getting underway in this type of activity were more interested in the idea of a land information system. Utilities generally wanted to have all of the information on the location of other utilities, especially those that were underground. Presently this is not available on a common base.

Private utilities wanted the following data types on a LIS:

Cable TV Lines	Streams and Lakes
Easements	Storm Sewers
Electric Lines	Streets as Traveled
Jurisdiction Boundaries	Street Rights of Way
Natural Gas	Tax Codes
Parcel Level Base Map	Telephone Lines
Rail Lines	Topography
Sewers	Water Lines

PUBLIC UTILITIES AND TRANSPORTATION

Agencies in the Public Utilities and Transportation sub-category were among the strongest supporters of the LIS concept. These agencies saw a significant potential benefit accruing to the operation of their own systems. This group perceives a wide range of data as necessary to make the LIS optimally workable. Public Utilities and Transportation users wanted to have the following data types on a land information system (not all of these types were needed by any one group within any one agency):

Cable TV Lines	Recorded Surveys
Curbs	Rights of Way
Current Land Use	Sewers
DLC Corners	Sidewalks
Easements	Soil Types
Electric Lines	Storm Sewers
Environmental Limitations	Streams and Rivers

- Established Elevations
- Flood Plains
- Geologic Conditions
- Jurisdiction Boundary
- Lakes
- Natural Gas
- Parcel Level Base Map
- Planimetry
- Railroads
- Street Address
- Street Grades
- Street Surface Conditions
- Streets as Traveled
- Telephone Lines
- Topography
- Traffic Volume
- Water Lines
- Zoning

PRIVATE ENGINEERING, SURVEYING AND PHOTOGRAMMETRY

Needs in this subgroup are strongly influenced by the requirements of land surveyors. Surveyors, in general, are the largest single group of information contributors to this needs assessment project. The data demands of this user subgroup parallel those of the preceding subgroups but are not so extensive. In general, private users saw themselves as both patrons of the system and providers of data (normally survey data) to increase its accuracy.

This users group wants the following data types:

- County Road Numbers
- DLC Corners
- Electric Service
- Flagging of Survey Problems (Overlap or Gap)
- Geodetic Control Points
- Parcel Level Base Map
- Planimetry
- Recorded Surveys
- Sewers
- State Plane Coordinates Easements of Major Points (e.g. Section Corners)
- Storm Sewers
- Streets as Traveled
- Survey Monuments
- Topography
- Underground Telephone
- Water Lines

Planning and General Government Administration

The user group has a diverse set of needs arising from the diverse functions performed. Planners are the most dominant members of this group and the requested data types in large part reflect this. This group also has the most diverse needs in terms of mapping scale.

Users need the following data types:

- Administrative Districts
- Parcel Level Base Map

Case Number-Past Actions
Census Tracts
Comprehensive Plan
Easements
Elections Precincts
Historic File of Land Division
Historic Sites
Important Buildings
Jurisdictional Boundaries
Lakes
Land Use
Legislative Districts
Neighborhood Boundaries
Planimetry
Private Utilities
Sewers
Storm Sewers
Streams and Rivers
Street Addresses
Streets as Traveled
Topography
Traffic Volumes
Vacant Land
Water Lines
Zip Codes
Zoning

Public Safety

Public Safety dispatch would be interested in using a land information system if it could be interconnected with the DIME file or if a base map suitable for their purposes could be generated from the LIS. At an administrative and planning level, there is a great deal of interest in an LIS. The data types listed below reflect primarily administrative and not dispatch needs:

Census Tracts
Dispatch Zones
Fire Hydrants
General Land Use
Hazardous-materials Locations
Jurisdictional Boundaries
Neighborhood Watch Boundary
Parcel Level Base Map
Planimetry
Police Reporting Districts
Street Address
Streets as Traveled
Topography

Chapter 3

ASSESSOR MAP USERS' GOALS FOR THE MULTIPURPOSE CADASTRE

This chapter presents goals assessor map users had for the multipurpose cadastre and for a land information system. Since it would have been impractical to subject all of the more than forty interviewees to the intensive, structured-choice situation of an ISM (Interpretive Structural Modeling) session, we extracted and distilled these goals from the user needs assessment interviews.

Many of the comments we received during the interviews didn't fit neatly within the confines of the questionnaire we had set up. These commonts could be characterized as relating to areas of concern a number of users had in regard to the impacts a multipurpose cadastre or land information system might have. We thought it would be valuable to include a summary of these comments before presenting the goals as we understand them.

Change

Respondents viewed the development of a computerized assessor map system as both a potentially beneficial and detrimental change. A number of users wondered how the new system would interface with their day-to-day operations. This was usually apparent in questions such as: Would the new system produce maps in a quarter-section format or have hard copies in addition to the graphic terminal displays? Would the new maps cost more? This uncertainity reflects a concern about the effects of the unknown system on routine operations. Many of the managers were pleased to be contacted in advance of a final decision on the form of the new mapping system. They felt that it would be potentially more beneficial to their organizations if they were kept up to date on system progress. Many managers felt that they might have some unnecessary problems if the system were to suddenly appear in an operational form. They perceived the need for the early establishment of a management level users group to help diverse users adapt to it and work out institutional relationships to allow the multipurpose cadastre to function smoothly.

On the positive side, most of the users felt that a new map system would reduce problems they sometimes face in their current use of assessor maps. They generally supported the concept of establishing a land information system through the cooperative efforts of the agencies now producing various types of maps. Some concerns were expressed about the magnitude of current investments in existing mapping systems. Most of the users of assessor maps thought that the change to a computerized system would have the potential to produce some increase in the efficiency of their organizations but they were not able to quantify how much or in what areas. They could visualize, though, that the development of a land information system would present a great opportunity in the long run. Several individuals working in the engineering area felt that a land information system based on a multipurpose cadastre would present a tremendous opportunity to do preliminary work on projects at much lower costs. The assessment of the positive nature of the changes resulting from a new system was made on an intuitive basis and not as a result of any actual experience with computer mapping.

Cost

One of the first responses to the idea of the County converting its current mapping system is: What will it cost my organization? All current users are concerned that the cost of obtaining and using assessor maps might increase to prohibitive levels. This was often expressed in terms of cost per map or cost of the purchase and operation of new equipment. In a number of cases the issue of cost was associated with the need to include new equipment in the long term capital budgeting process of an agency.

The issue of buy-in cost came up a few times (i.e., was the County going to attempt to recover its expenditures for the production of the computerized assessor map by charging an initial fee of some type?) The agencies that had data to contribute to the process of establishing a MPC were concerned about the cost of getting the data onto the system. There was a consensus among many of the organizations that it was appropriate for the County to recover the actual operating costs associated with an individual organization's use of the system. This cost was generally discussed in terms of CPU time and a portion of the necessary direct staff support for system operation. However, there was some concern that the County would try to make the system into a revenue generator.

Accessiblity

A number of users had questions about the accessibility of the new mapping system. They seemed to desire unlimited user access from a graphics terminal on a time sharing basis. Users, especially those contributing data into an MPC, did not want to have problems accessing data (particularly if it were their own). These concerns were apparently based on a concept of the land information system as a centralized store of files, rather than one of a number of independent data bases using data communications to share read access or copies of data sets between users.

Part of the accessability problem was expressed in terms of equipment compatibility. A number of agencies and organizations have already made relatively large investments in data processing systems. For example, Troutdale, Gresham, and some divisions of the City of Portland are using a Digital Equipment Corporation VAX minicomputer for data processing. This hardware is compatible with the Synercom system recently purchased by PP&L but not directly compatible with the Intergraph system at PGE. There is an apparent need for the establishment of an ad-hoc user technical committee to serve as a resource in the process of making the new system workable. It could also help educate users in the concepts underlying data sharing and computerized mapping.

Usability and Format

User mapping needs require that the system have enough flexibility in the form of its outputs to serve many different map and report formats. Many users want simple access procedures for accessing maps in the format they are used to. The most common request was for the ability to call up quarter-sections using existing map reference numbers. Additional common map formatting needs, such as windowing to a study area or changing scale, can be accomodated more efficiently with a digital data base.

Many users have developed different map formats in response to routine work requirements. For example, some agencies want the names of streets placed within the street right of way in all cases while others want the street names placed outside the right of way in all cases. These two different requirements and many similar ones will need to be assessed in developing the system.

Map Scale

Most system users will need assessor maps at a scale of approximately 1 inch = 100 foot, primarily for detailed mapping work. Many users, involved in the construction and management of public facilities, start their work with maps at this scale. In heavily developed areas, it is often necessary to change to 1 inch = 50 foot or 1 inch = 20 foot because of detail requirements. In heavily developed areas it would be beneficial if the system had the ability to produce cross-sectional drawings.

The same users of 1 inch = 100 foot scale maps also work with the 1 inch = 600 foot maps. There are also other users that work mainly with these large area maps. The County needs to maintain its 1 inch = 600 foot base map in order to meet the needs of these users. The major question associated with mapping at this scale is, will the County continue to produce this map? Many users are concerned that the conversion of the assessor mapping system to a computerized system will result in the elimination of this base map. This would leave them without a base map to meet their needs. A question that needs to be answered is: can a 1 inch = 600 foot base map be produced directly from the the new digital mapping surface or will some addtional work be required?

The third frequently used scale of mapping is a generalized road network map at 1 inch = 2000 foot. This is a State Highway map and is manually maintained. This map is not directly related to the assessor base maps.

Security

The security of the data layer within a MPC is an issue with many agencies that might be asked to supply data. They want to prohibit unauthorized alteration of the data contained within the layer(s) that they have constructed and are responsible for. These users are not concerned about individual users making maps using their data, i.e., reading it. They are concerned with the safety of the data once it is on the system. As with the accessibility issue, this concern may be resolved as users become more acquainted with the capabilities and constraints of data communications. In general, since users' data bases will remain at their physical sites, they will be able to control reading and writing privileges against them.

Goals

Users' goals for a multipurpose cadastre, as abstracted from the interviews, include:

- **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 assessor's goals in that elements identified (in the discussion of assessor's goals, 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' set with 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.

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 investigated users' goals for a land information system (noting that the main actors in the multipurpose cadastre -- our clients -- as participants in the land information system, share these goals as a matter of definition):

- **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) the concept of 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.

Section Two

Technical Issues

Chapter 4

TECHNICAL REQUIREMENTS AND STANDARDS; MPC SYSTEM CONCEPT

This report section looks at technical design issues raised, explicitly or implicitly, by the investigations of the first section of this report. This first chapter outlines general issues of geographic information system design. In succeeding chapters, we will look at other technical issues raised by the special nature of cadastral mapping, and at approaches to address these issues.

In this chapter, we first present the idea of a design standard in the form of a series of questions which a multiple purpose geographic information system must be able to answer if it is to be successful. (The questions themselves are listed and discussed in Appendix D.) Next, we put these questions together with the goals, objectives, and concerns identified in the first section of this report and present a system concept for a multipurpose cadastre which could serve as the basis for a land information system.

Technical requirements and standards

> The value of any data system can be measured in terms of the questions it can answer and the facility with which it produces these answers. In this article we set forth the technical requirements -- the standards -- for a multipurpose geographic data system by asking questions of the various bodies of knowledge relevant to geographic data systems. We also ask questions about the system, particularly concerning quality control, extensibility, and maintainability.
>
> Standards expressed as a set of questions are a kind of performance standard, in contrast to standards that prescribe methods or schemas to be used. The performance standard is completely general; it applies to any system regardless of the encoding methods, for example, DIME, grid cell, triangulation, or raster. Just as we can aswer questions by examining a map, we can answer questions by querying a computerized version of the map. The particular questions we ask as a test of a system are determined by a mathematical understanding of the nature of maps. In this way, we determine how well a digital map performs in comparison to an ordinary paper map.

The underlying foundation of a geographic data system, the part describing the land itself, is geometrical. So our questions regarding the foundation and its completeness are asked in geometrical terms. Likewise, geographic areas are related to each other in set-theoretical terms. So we ask geographical questions using set theory.

Examples of geometrical questions are:
What is the location of a particular point in, say, Universal Transverse Mercator coordinates?
What are the abutters to a particular region in counterclockwise order?
What is the slope of the land at a particular point?
Examples of geographical questions are:
What Zip Code areas occur in a particular census tract?
Are a particular city and county co-extensive?
What is the smallest legal jurisdiction covering a particular neighborhood?
Which of the possible types is a particular feature (river, highway, railroad,...?)
Questions we will ask about the system include:
How are new applications implemented using the existing foundation?
Does the system guarantee that the data are consistent?
What is the rate of data entry?
[White, 1984]

As was mentioned above, the actual list of questions is presented in Appendix D.

MPC system concept

This presentaton of a multipurpose cadastral system concept takes the form of a series of views on the system at three different levels. The broadest vew presents the MPC as an element in a larger system. If the view at the next level down -- the view that users have of the system in the context of their day-to-day interactons with it -- is called the **system** view, then this higher-level view may be called the **metasystem** view. In like manner, the view on the system at the level below the system level -- the level at which we are considering the system in terms of its internal parts and processes -- may be called the **subsystem** view.

Figure 1 depicts the metasystem view, or what might be called a designer's-eye view, of a multipurpose cadastre. We would like to mention some points to keep in mind while examining it.

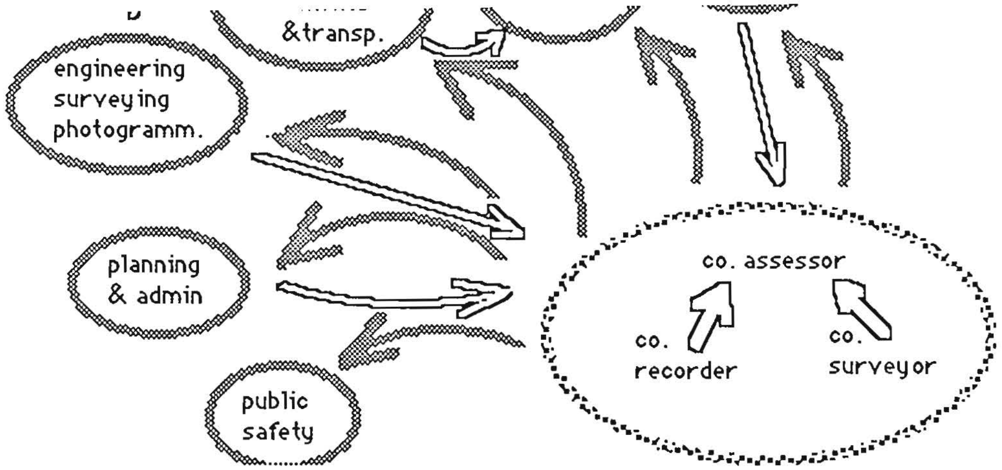

Figure 1. The Metasystem View on a Multipurpose Cadastre

First, the figure should be thought of as a view "from above". No system user, including those in the "multipurpose cadastre" area, would have quite this perspective in the course of using the system.

Second, the depiction at hand is highly schematicized. The arrows indicate some major flows of data, but are by no means exhaustive of all the possibilities or actualities. Neither is any hint given in the figure of the possible combinations of format or media in which the data may be found.

With these caveats in mind, then, how does Figure 1 help us to understand a multipurpose cadastre as part of a land information system?

First, the multipurpose cadastre forms a subsystem of the land information system. It is formed, in turn, from the mapping and cadastral functions of a small set of county agencies closely involved with land records.

Secondly, other city, county, and private agencies receive a major data flow from the multipurpose cadastre. This would consist primarily of parcel location data -- the common base map -- although other data might also be included in the flow from the MPC to a specific agency.

Thirdly, other data flows occur from specific agencies to the multipurpose cadastre. These might be locational data, aiding the MPC in locating parcel boundaries (e.g. a series of planimetric maps from photogrammetric engineers) or update data about parcels (e.g. improvements data from title companies), aiding the valuation process.

Finally, some data flows occur between non-MPC agencies. A wide variety of possiblities exist, some of which can be deduced from the "wish lists" obtained in the map user interviews.

At the **system level** -- the level of user interaction with the MPC -- each participant in the land information system will have a "window" with a different view into the multipurpose cadastre. A general model of such a window is shown in Figure 2. In this figure, the user perceives the multipurpose cadastre as a black box with certain inputs and outputs: data, resources, questions, and answers. For each user rôle (here defined as an actor with a set of questions and a set of expected answer forms), and each data supplier (each with his/her own set of data) -- and, actually, for each resource supplier, the system will exhibit a different set of behaviors. (At the next level down, it will be necessary to specify exactly what is "inside" the system from each actor's point of view. At this level, what is required is to detail what each person (rôle) interacting with the system expects it to do.) As with the metasystem view, the present report will necessarily present only a schematic idea of the lists of questions, answers, and so forth that will have to be fully realized.

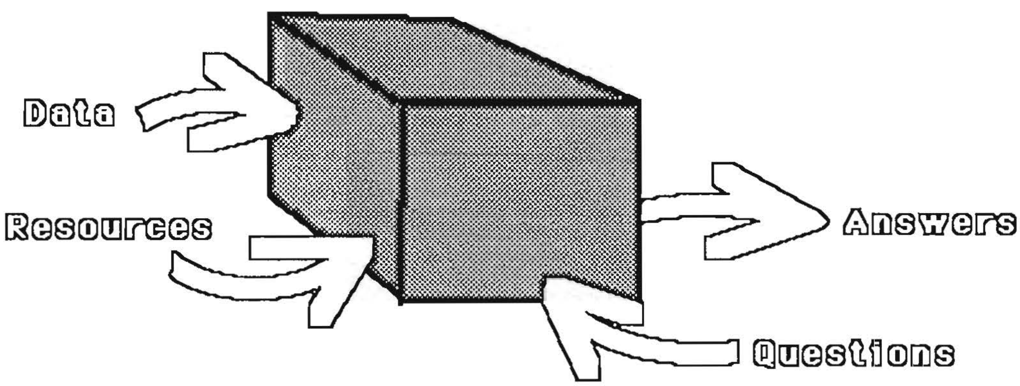

Figure 2. Generic System Level View on the Multipurpose Cadastre

For instance, we can visualize the assessor posing such questions (or requests for data) as:

- display or plot a map (in the usual assessor's format) of a particular section, quarter section, or sixteenth section, given the map number
- display a particular parcel (showing its shape and orientation) given the parcel identifier
- find data (area, owner, assessed value, etc.) about a particular parcel, given its parcel identifier or its location on a map (by pointing)

- find data about a group of parcels, given the jurisdiction or other data common to the group

From the list of questions, we can deduce something about the forms of answers expected: plotted maps (of a certain scale, format, and content), video displays (usually maps but perhaps also graphs and charts), and reports, usually of a predefined format.

Data going into the system from the assessor's office include:

- new partitions
- changes in tax rates
- updates to property assessments

The resources going in, from the assessor's point of view, would be the technicians and cadastral cartographers working to update the data in the system and the hardware, software,and programming effort supporting them.

The county surveyor will have a different set of questions, including:

- plot/display the survey monuments in a certain area (by map location or pointing to it on the screen), showing the monuments' relation to roads and buildings
- plot/display the control monuments in a certain area
- plot/display survey lines for surveys of a certain order of accuracy
- print a report of survey monuments in a certain area, their coordinates in the State Plane Grid sytem, the order of accuracy of their location, and the reference number of their locating survey

Data going in, for this user, includes:

- new field notes (coordinates of points computed and adjusted; data quality)

Another user, such as a county planning agency, would have questions including:

- print a report showing the parcels in a certain area that are in a commercial zone and have a residential use
- display a map of parcels with residential use within a certain distance of a specified object (an airport, say)
- plot a map of a particular census tract and print a statistical report using the census data

Data for the planning agency might include:

- changes to planning area boundaries
- changes to zoning definitions
- updates to census data
- changes in land use

A title company's questions would include:

- display/plot a particular parcel (identified by company's ARB number)
- print a report of data about a particular parcel
- print a report of data about parcels larger than a certain size, with certain allowed land uses, in a certain area

Title company data would include:

- changes in ownership
- improvements

When we go down one more level (Figure 3) to gain the **subsystem** view -- to "look inside" the MPC as it appears to each user -- we find once again general similarity but differences in specifics. The general model can be thought of as containing three objects: a data capture capability, a data storage capability, and a capability to decipher user questions and provide answers. These three functional subsystems have been characterized [Lendaris, 1985] as the data **selector**, data **store**, and data **massager**.

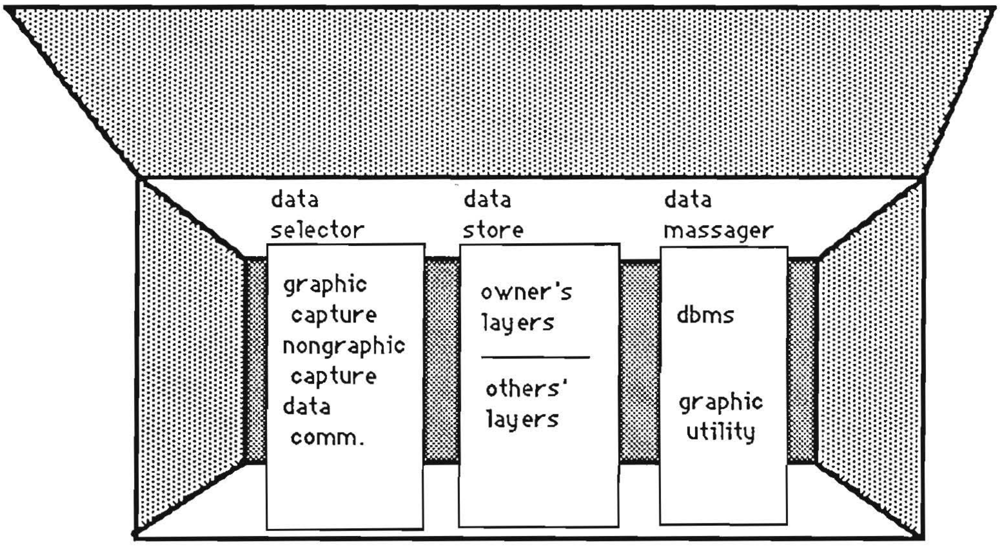

Figure 3. Generic Subsystem View on Multipurpose Cadastre

From the point of view of a "generic MPC user" (in the sense of question provider/answer expecter) the selector contains capabilities to convert graphic or written **locational** data (maps, imagery, survey field notes, deeds) to digital locational data (this might include digitizers, scanners, coordinate geometry (COGO) software, or higher-level language routines to convert deed descriptions to location or shape rules, objects, and parameters); other capabilities to convert **attribute** (non-locational) data to digital form (including menu software, keyboard and mouse command interpreters, and so on); and capabilities to **capture data** from other information systems in the land information metasystem (data communications software, protocols, and the like).

The data store contains two types of data sets or layers (the name is from analogy with map layers or overlays, each of which contains data relating to a particular theme): the **owner's layers**, maintained by the user holding the particular view under discussion, and **others' layers**, maintained by other users (although a copy of another's layer may physically reside on your system).

Finally, the data massager for our generic user contains a **dbms (database management system)** and a **graphics handler** capable of acting in concert to answer questions put by the user from items in the data store.

Chapter 5

THE CADASTRAL LAYER OF A MULTIPURPOSE CADASTRE

This chapter examines some of the considerations following on the goals identified in the first part of this report, and the technical requirements, standards, and system concept introduced in the previous chapter, as they relate to the preparation and maintenance of cadastral data -- especially cadastral location data -- in a multipurpose cadastre. The first part of the chapter examines the concept of the **base layer** (registration layer), its content, compilation, and relationship to other layers (locational data sets) of the multipurpose cadastre. Next, we look at various possible combinations of base layer **content** and compilation **methods** to draw out their impacts on the problem of updating and incrementally upgrading locational data. In discussing the requirement for capturing the source data which results in derived locations, we confront the limitations of presently available mapping systems. We then discuss the concept of the life-cycle of a technology, and how this consideration affects the goals identified in the first part of this report. Finally, we present a discussion of strategies for management of the large volumes of data involved in a cadastral data layer.

Base layer and non-base layers

(This discussion assumes that we are talking about a flat earth, which is the usual case in cadastral mapping.)

It is possible to place a pair of maps in relation to each other if there are on one map two or more points having a known spatial relation (distance and direction) to two or more points on the other map. The simplest case occurs when two points on one map are "the same" as two points on another map drawn at the same scale; one of the maps could be overlaid directly on the other by matching up "the same" points that appear on both maps. More generally, it is not necessary that the points in question be "the same" or that the map scale be identical as long as there are known relations between the points and the scales of the maps. The relations allow the locations of at least two points on the first map to be placed on the second map. If necessary, a third map is produced preserving the relative locations of objects, but at the same scale as the first map. This third map is then overlaid on the first, matching up points. By extension of this principle, a whole series of maps can be related to each other. In the same way, the relationship of map to ground can be determined if there are known relations between points on the ground and points on the map (and if the map scale is known). What we're really talking about here is scaling, rotating, and translating one map to overlay another. With paper maps, this can be done directly, by moving the maps over one another. In a computer-aided system, these operations are performed mathematically, by deriving a grid coordinate system for each map and mathematically transforming one system to the other.

In a map-overlay system, that map containing points which all other maps can relate to is the **base map**, and the other maps are **overlays**. In a computerized mapping system, the analogous data layer is called the **base layer**, while the other layers are usually identified in terms of their thematic content, as, *e.g.,* the "hydrography layer", the "right-of-way layer", and so on.

Objects in the base map, or base layer, have absolute location as far as the system is concerned. The location of objects in non-base layers is known relative to objects in the base layer.

Objects having relative location may be located using

- one location **rule,**
- one or more locating **objects**, and
- zero or more locational **parameters.**

For all presently available computerized mapping systems, the rule used to locate object in other layers is: apply offsets in the x and y directions from the grid origin in the base layer. The reference objects are the grid origin and "north", and the parameters for each object are the values of x and y.

The location of cadastral objects

Let us consider the task of a person drawing a cadastral map from original source documents, which include:

- lists of coordinates of geodetic survey mouments;
- property surveys and subdivision plats which may or may not be tied to geodetic monuments;
- deeds and other instruments which may or may not be based on survey measurements;
- aerial photographs and topographic maps;
- and such other maps and drawings as engineering sketches and right-of-way strip maps, city and utility company facility maps, and so on.

These source documents, plus a fair amount of judgement and experience, are required so that the cadastral mapper can make a series of choices as to where on a sheet of paper to place the symbols depicting the boundaries of parcels. In making these choices, the cadastral map maker follows many of the logical steps that a surveyor or land court would take in defining the location of parcel boundaries -- except that where a surveyor or land court is usually concerned with a single parcel or a small number of adjoining parcels, the cadastral mapper has the job of fitting together a large number of parcels into a coherent whole.

Fortunately for the mapper's peace of mind, the final document is not a legal one in the sense that it defines the locations of parcel boundaries; but a conscientious map maker, in reporting the positions, performs much more than a simple drafting job. The placement of a cadastral object on a map sheet is the result of a long chain of judgements, based on the evidence available, to determine the spatial relations between a number of physical and abstract objects.

The knowledge about those judgements, which essentially say why a particular object is located where it is, is not accessible from the arrangement of ink on paper which constitutes the final product: the cadastral map. On the map, the location of objects -- relative to the expanse of the sheet itself, to the state plane coordinate system, to nearby survey monuments, and to legal (abstract) objects -- is all of the same order. It is not possible to distinguish nearby property corners that actually are important in defining the location of a certain corner from those which may not be relevant at all. Physical or topological proximity is not a reliable criterion; what is important is the procedure actually followed, or that would be followed, by a land surveyor in establishing the point's location using the legal definition.

Having access to the knowledge of the why of location becomes crucially important when it is desired to update the map, whether this means adding new lines (as in subdividing parcels), or changing the position of old ones (as when a more recent survey finds a new location for a survey control point or a property corner monument). In most cases, it is necessary to refer to the original sources for a portion of the map (the deeds, surveys, and so on referred to earlier) and retrace the steps mentioned above. In the case of a simple parcel partition, the effort involved is trivial; in the case where the location of an important point is redefined, it is not.

One fact not generally acknowledged is that locations of important points -- monumented section corners and the like -- are being redefined continuously. Every time a new subdivision plat is filed, a measurement is given showing the relation of previously established reference corners to the new points established by the surveyor. Often a measurement is made between points established in previous surveys. Frequently these measurements, taken by themselves or in conjunction with other work, imply locations for these already-established points significantly different from the ones used on the cadastral maps. As the requirements for survey performance become more stringent and as survey technology and practices improve, it is apparent that later monument locations will be more accurate than earlier ones.

However, if the locations of the witness monuments are to be changed, how will that affect the locations of other parcel boundaries which have been established using these reference corners? If the job is to be done correctly, the source documents have to be retrieved and consulted and the whole jigsaw puzzle pieced together again: the map needs to be reconstructed.

(It should be stressed that accuracy in this context pertains specifically to the geographic, not the legal, location of a monument; on the other hand, the redefinition, by agreement or by order of a land court, of the legal location of a property corner can also have far-reaching consequences for the location of property corners whose location is known by reference to that corner.)

In practice, if the difference in locations is not too glaring, the new subdivision is fitted into the space available on the map and the changes are allowed to accumulate until a large area -- a whole map sheet, say -- can be reconstructed all at once. This is an appropriate strategy for a paper map system, where physical update entails a fair amount of wear and tear on the recording medium.

A computer-based mapping system, using a magnetic recording medium which can be erased and updated with virtually no physical wear, presents the potential of a continuously updated layer of cadastral data. There is also a need for more frequent update than has been achieved by cadastral mapping agencies. In the first part of this report, we noted that many agencies desire more frequent update of the parcel layer than now occurs, and, in fact, several agencies desire continuous update. In this context, knowledge of the current location of objects is a basic necessity. Unfortunately, computer-aided mapping systems based on the conceptual model of paper-map systems have the ability to present only the most recently updated locations of cadastral objects. The actual currently known location may not have been entered into the system yet due to the involved nature of the location-update task.

It should also be apparent that this kind of knowledge of location is not sufficiently modeled by a topological data structure. Such a structure will capture the present spatial locations and the relations of points to lines, lines to areas, and so on, in a way that non-topological structures do not. But topology is not geometry. As White [1984] notes, the metric relations of objects must also be captured. And as we said above, this is done at present by storing the location of objects relative to the origin of a coordinate grid system.

The essential problem with present computer-aided cadastral mapping systems is that cadastral locations have been treated as **source** data rather than **derived** data. That is, what is stored in the database is the final product of a series of computations and judgements, rather than the algorithms and data which model those computations and judgements. The problem is compounded when the cadastral layer is defined as a base layer. Objects in the base layer must logically have absolute location as far as the system is concerned; but in the real world, cadastral objects' locations are known only in relation to other objects, which are also represented in the system. This results in paradoxical situations, in which an object may simultaneously have more than one location, or none at all [Kjerne, 1985].

While present mapping systems do not model the realities of location of objects in the world, it is possible to speculate about approaches which would. Object oriented languages, for instance, are powerful and flexible tools used in building models of real-world systems. In a language such as Smalltalk-80, for instance, every entity in the system -- a file, a processe, a device -- is an **object**, an entity which has a certain amount of private memory and the ability to respond to messages sent by other objects. The languages are easily expandable and modifiable, with new classes of objects inheriting characteristics of their parent classes, with differences specified by the programmer. It is possible to define objects in these languages which model the behavior of entities in a particular system.

In modeling the behavior of cadastral objects, we would want them to have the capability to determine their location -- upon receipt of the query for same from another object -- by accessing their particular antecedent objects, rule, and parameters. In so doing, of course, the antecedent objects would have to determine their locations in a similar fashion, passing the location queries recursively back until a base-layer location (a geodetic control point or a point "known" to have not been updated since the last query) was found, and then passing the locations forward through the chain until the original message had been replied to.

An object-oriented approach could thus model the true structure of knowledge about location. The problem, of course, is that no such approach has as yet been implemented, nor even tested. The fact that it is recognized as a problem is indication that, sometime in the not too distant future, there probably will be systems which treat location as derived, rather than source data. This will have obvious impacts on the decision on choice of systems now.

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. Not long ago, two authors of the present report [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 cadastal 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 (base) layer for users with other data layers.

cadastral layer compilation method	base layer content A geodetic control	 B planimetric data	 C no base layer
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.

<u>1B Planimetric data base layer/computed cadastral layer</u> 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, map, or orthophoto image showing 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 <u>see</u> 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.

<u>1C No base layer/computed cadastral layer</u> 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 <u>some</u> connection to control points located on a common grid. But since the result is a base layer consisting of a mixture of cadastral objects and control points, it will be hard for other users to be confident of accuracy in registering their layer. 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 poor to fair framework for other users to register their data, again depending on how many control points were actually used.

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 obtaining among cadastral data. All the methods assume that locations of objects in the cadastral layer will be described by reference to the grid origin. Paradoxically, having no base layer (as in column C) makes it easier to update and revise locations, since any new partition or change in location of a property corner can be done with an edit in one layer. But with a separate base layer, as in columns A and B, a revision in the location of a geodetic monument or a move in a river channel -- changes which cause revisions in locations of property boundaries -- will result in a complicated, error prone series of operations.

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 report, neither of the options of column C seem appropriate, primarily because they do not address the "accuracy" goals identified for both MPC agencies and assessor map users. Regarding the other four alternatives, it should be noted that the MPC agencies' 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 description of the location for cadastral data is not captured -- whether or not it can be used to automatically 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.

The requirement to capture the cadastral description literally adds another dimension to the matrix we considered earlier. We can discuss the alternatives available by portraying the various combinations in a three-dimensional matrix which looks something like those dividers inside beer-bottle boxes (Figure 1). The rows are the same as those in the matrix in Table 1; the columns are the same as the first two columns, omitting column C; and along the third dimension we have ranged three identified alternatives for the capture of location description (or decision) data. "Derive location data" means: develop a cadastral layer schema which will allow the multipurpose cadastre to automatically update the locaton of individual cadastral objects when their location rule, reference object(s), or parameter(s) are changed. "Capture decision data" means: use a conventional cadastral layer schema to store the location of cadastral objects, but 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 final set of cubicles is labled "No capture" of decision data.

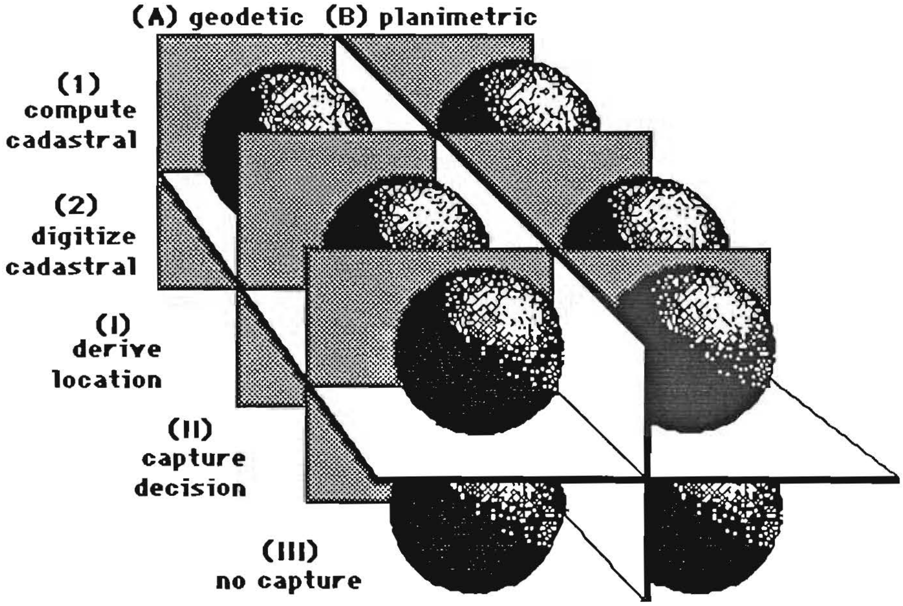

Figure 1. Base Map Content, Cadastral Layer Compilation Method, and Decision Data Capture

Logically, of course, certain of the conditions or options considered do not fit with each other. If location data is gathered by digitization rather than compiling from primary sources, no real decisions have been made about the locations of individual objects. We will only consider the alternative combinations marked by the little spheres.

Combinations 1AI and 1BI (Geodetic control base layer *or* planimetric base layer *and* compute cadastral layer *and* derive location data) meet most of the goals identified in the earlier part of this report, with the exception of the "minimize cost" goal. The fact is, a system has not been developed which will store the location decision made by the cadastral map compiler and use that data in answering a location query. An MPC-producing agency wishing to persue this option would find itself involved in a research and development effort probably inappropriate to its mandated rôle.

Combinations 1AII and 1BII (Geodetic control base layer *or* planimetric base layer *and* compute cadastral layer *and* capture decision data) would require a certain amount of development effort to devise a 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 data base organization or functionality. 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. This option might be persued if the MPC-developing agencies forsaw the possibility that a new system that could use the captured decision rules would be available, and that it would be cost-effective to convert, before it would be time to reconstruct the cadastral layer anyway.

Combinations 1AIII, 1BIII, 2AIII, and 2BIII are four of the six combinations that were discussed in the previous section -- the two-dimensional matrix. One of these combinations would be chosen if it seemed likely that the MPC would move to a new system which captured and used location decisions, but that it was cost-effective to reconstruct the cadastral layer at that time. Choices between the option of digitization or reconstruction (computation) will depend mostly on the perceived value of a one-time reconstruction of the cadastral layer as against the (much) lower cost of digitizing the assessor maps and fitting them to geodetic or planimetric base data.

Map Libraries

Large volumes of data are involved in multipurpose cadastre development and maintenance. Data quantities of 300 megabytes to one gigabyte are the norm. This kind of quantity requires special strategies to avoid interminable waits for the answers you want as the system searches through volumes of data. Nicholson [1984] outlines three strategies for organizing the data base structure, or map library.

> ...The first model, commonly referred to as a faceted or facetized model, physically separates the total geographic data base area into many relatively small files. This is usually achieved by segmenting the area into a grid of regular contiguous polygons or facets such that the data falling within each facet can be stored in a separate file or set of files. The result is a nearly constant response time when searching the data base for an entity when geographic location is the search key.... Problems with this model occur due to the creation of more files than the operating system can reasonably handle, the segmentation and rejoining of surface structure features crossing facet boundaries, and the explicit storage of connected network relationships....
>
> A second spatial model stores the total geographic data base area in a few relatively large files. Instead of passing data to the host computer for comparison with the search criteria, the host passes the criteria to a slave processor that performs the search on the storage device. In this manner only data fulfilling the search criteria are actually transferred to the host.... Although response time is comparable to the faceted model, some problems occur due to the need to store data in contiguous files on the storage device.... Other problems occur with maintaining these large files on a daily basis where backup procedures can become costly and time consuming.

> The third spatial model makes use of large files but logically segments the total geographic data base into contiguous areas. This approach combines the advantages of a faceted data structure without the need to physically break and rejoin entities crossing facet boundaries. Variable scale faceting schemes such as quad-tree structures and Generalized Balanced Ternary addressing have been used to implement this type of model. Search times for these implementations are the fastest of the three spatial models but, since they rely upon state of the art algorithms and technologies, have received the least amount of testing in actual applications. [Nicholson, 1984]

The choice of which model to use will depend on the kind of spatial relationships involved in the data layers. For most uses within a cadastral context, a data base segmented into separate files corresponding to assessor maps is probably most appropriate. This map library structure is a type of facetization in which, instead of having the geographic area divided into uniform tesselations, each subarea has a unique boundary description. Other users of the multipurpose cadastre data, within the land information system, may have differing map library structures to better fill their requirements. The image of the cadastral layer stored on another user's system will have to be modified by that user to conform to the map library format of their system.

Chapter 6

THE GEODETIC CONTROL LAYER AND THE PROPERTY AND ENGINEERING SURVEY LAYER OF THE MULTIPURPOSE CADASTRE

The geodetic control layer

> Any accurate mapping project requires the establishment of a system of survey control. This survey control consists of a framework of points whose horizontal and vertical positions and interrelationships have been accurately established by field surveys and to which the map details are adjusted and against which such details can be checked. The survey control system should be carefully designed to fit the specific needs of the particular map being created. For multipurpose application, it is essential that this survey control system meet two basic criteria if the maps are to be effective planning and management tools. First, it must permit correlation of real property boundary line data with topographic, earth-science, and other land and land-related data. Second, it must be permanently monumented on the ground so that lines on the maps may be reproduced in the field when land-use development and management projects reach the regulatory or construction stage. [NRC, 1983].

The multipurpose cadastre will require a network of control points on the ground which can be related to property boundaries. But how many points, of what type, how far apart? How shall the mapping system store and process information relative to the control points? These and other design issues must be addressed keeping in mind the specific cadastral mapping situation in Multnomah County.

PROJECTION AND GRID

Possible grid systems on which to base the multipurpose cadastre are: Universal Transverse Mercator (UTM), latitude and longitude, State Plane Grid, or a local grid system. UTM is used by the military worldwide, but has no other advantage over other systems. Latitude and longitude has the advantage of being universally compatible with other systems, but its cumberousness in computation and unfamiliarity of use among local surveyors are telling disadvantages. A local grid system could be quite simple to work with and be tailored for the surveying situation in the county (without, for instance, the necessity to multiply distances by a grid conversion factor, as is necessary for high precision in the State Plane Grid system) but would require conversion to a common grid wherever surveyors worked in the border areas.

Local surveyors are gradually becoming more used to working with State Plane coordinates. The system is accurate enough for multipurpose cadastre use, even without use of a grid conversion factor (which is needed to obtain distance accuracies greater than 1:10,000) and it is in use on both sides of the county line. A number of points have been located and control survey measurements made in Multnomah County using the Oregon State Plane Coordinate System, North Zone. It appears expeditious to use a coordinate system which is already in wide general use -- especially since Oregon Department of Revenue calls for this system in its cadastral mapping specification [DOR,1979].

One consideration to be kept in mind is that the survey datum for the entire North American continent is in the process of being adjusted [Burkholder, 1985]. This new datum -- called the North American Datum of 1983, or NAD83, replaces one which had been in effect for over 50 years, called NAD27. Under NAD27, the horizontal, or latitude and longitude, position of each higher-order survey monument in North America was computed relative to a first-order monument in Kansas and a mathematical surface called the Clarke Spheroid of 1866. The datum adjustment means that the positions of these points will be computed anew relative to several hundred first-order monuments located using satellite surveying technology and a new figure of the earth. In practical terms, the latitude and longitude of high-order control monuments in the Multnomah County area will change by around 150 feet. In general, the positions will not shift relative to each other by any significant amount. The United States Geological Survey is preparing lists of new monument positions, and will send these out to interested agencies when the adjustment is completed -- probably Fall of 1985.

The State Plane Coordinate system, since it is based on latitude and longitude, will also be affected by the datum shift: the coordinates of points in this system will change along with their latitude and longitude. Care should be taken that new, rather than old, monument coordinates are used in the computerized cadastral system, since the old system will not be maintained after a certain date.

The new monument positions published by NGS will, of course, be only for monuments in the NGS control network. Other points, surveyed in by other agencies, also have State Plane coordinates, are implicitly tied in to the geodetic control net, and will require to have their positions converted to the new datum. Three methods will be available:

The first method requires a requesting agency to submit observations, tying the new points to the NGS net, to the NGS, which will compute and adjust the new positions. The observations must be of third-order accuracy, and sent to the NGS in machine-readable format (using the NGS "Blue Book" record setup). The new points must be permanently monumented.

The second method is to compute and adjust new observations in-house, extending control from points with known NAD83 coordinates.

The third method is to simply transform old coordinates of points using an average Δx, Δy from points in the neighborhood with new and old coordinates. This method, of course, does not provide a check on the old coordinate values of the points being transformed.

The agencies involved in defining the new datum and in the new State Plane Grid systems nationwide also faced the choice of which units of measurement to use henceforth. Nationally, the geodetic system will use the metric system, and provide conversion constants and coordinate values to the various State Plane systems in meters and allied units. Most states, including Oregon, which have revised the statutes defining their State Plane system to conform to the new datum, have shifted from the old "survey foot" to the "international foot" as a supplemental unit to the meter. The international foot and the survey foot differ by approximately one part in ten thousand.

It bears mentioning that the national vertical datum is also in the process of being adjusted. This is probably not a pressing matter in the definition of standards for the multipurpose cadastre, since storage of vertical location of objects is something which can be implemented later in the development of the system. At the time such data will be stored, though, it will be necessary to convert the wide variety of vertical datum planes in use in the county to a common plane.

SPACING AND MONUMENTATION

Determining the appropriate spacing for control monuments in the field addresses the goal of improving accuracy of boundary location in two ways. First, in the initial production of the survey information layer (which serves as a substructure to the property boundary layer), the position of points on recorded property surveys can be computed and adjusted between survey control points. If these control points are widely and irregularly spaced, errors in recorded property surveys may be perpetuated over wide areas. Secondly, appropriate spacing allows property surveyors a reasonable chance of locating recoverable reference monuments in the area they are working, which facilitates production of more accurately located property surveys. These, as they are filed at the County Surveyor's office and entered into the cadastral mapping system, improve the accuracy of boundary location.

<u>Procedures and Standards for a Multipurpose Cadastre</u> [NRC, 1983] recommends a monument spacing of 0.2 to 0.5 mile in urban areas and 1 to 2 miles in rural areas. Much of the area of eastern Multnomah County was originally laid out using the Public Land Survey System, with township, section, and quarter-section corners; center of

section monuments have been set out in some areas. These monuments are spaced at half-mile intervals. These points serve well as reference framework for rural and semi-rural areas. There are a number of advantages for using these points where they are available in Multnomah County: 1) they are regularly spaced over the area; 2) the points are usually easily recoverable and intervisible; 3) many of the points already are tied in to the State Plane Coordinate grid; 4) they are already referenced by a number of recorded property surveys.

While a good deal of the county was laid out using the rectangular survey, a small part was originally partitioned into Donation Land Claims (DLCs). As with the section division of land, these original patents are the references for later divisions of land. Many of the DLC corners are also already monumented, although far fewer have been tied into the State Plane Coordinate system. Since the DLC lines are irregular, the monuments are not regularly spaced, and are often farther apart than the 0.2 mile recommended for urban areas. This is especially unfortunate since the DLCs are located in the earlier-settled parts of Portland, which tend to be the more urbanized, built-up sections. In this area, though, city surveying agencies and private engineering concerns have established permanent monuments at street centerline intersections, along street rights of way, and at other points. Thus it would appear that permanent monuments which are tied to property surveys already exist in most of the county at an appropriate spacing to serve as a geometric framework (with the possible exception of center section points). Only a small percentage of these, however, have been tied by survey to State Plane Coordinates.

Monumentation of cadastral control points allows field surveyors to recover and use them in establishing property corners in new field work. We noted above that most of the likely cadastral control points are already monumented. A relatively modest monumentation program, phased over several years, would undoubtedly suffice to fill the gaps.

Surveyors will need a ready source of information about the monuments in order to recover them. For each monumented point, this source should provide access to the description, recovery notes, coordinates (if available), accuracy of location (if available), and distance and direction to reference monuments and natural backsights.

ACCURACY OF THE CONTROL LAYER

In 1984, the Federal Geodetic Control Committee issued a revised set of standards and specifications for geodetic control networks. The classification of horizontal and vertical surveys remained unchanged from previous publications, but

the rules for determining the classifications had been refined in order to assess more exactly the effect of both random and systematic errors. Thus the horizontal standards remain:

Classification	Minimum Distance Accuracy
First-Order	1:100,000
Second-Order, Class I	1:50,000
Second-Order, Class II	1:20,000
Third-Order, Class I	1:10,000
Third-Order, Class II	1:5,000

The "distance accuracy" is the ratio of the relative positional error of a pair of control points to the horizontal separation of those points. The classification of a horizontal control survey is obtained by the following sequence of steps:

a. The survey has been accomplished employing specifications designed to yield an intended distance accuracy.

b. The coordinates of points in the survey are obtained by an internal (minimally constrained) least squares solution, and distance accuracies based on this are computed. The survey is then classified according to the least accurate results.

c. A least squares solution is carried out combining survey data with previously established control from the network into which the survey is to be incorporated. Statistical tests then indicate if the new survey contains substantial systematic error (with respect to the network). If the result is satisfactory, then the classification assigned in b. holds. Otherwise, the survey and network measurements must be scrutinized to find the source of the discrepancy. [Chovitz, 1985]

While many monument points in Multnomah County have State Plane coordinates, the surveys establishing these ties only rarely follow the specifications above or the ones previously in force, making it impossible to state the order of accuracy of location for those points. Surveyors operating in the county have, in many cases, used the monuments, coordinates, and measurements many times, and feel confident of their accuracy; however, in the absence of explicit information about the procedures used to establish the loction of a point, a statement about the accuracy of its location must remain qualitative. Furthermore, any points located using these points as reference, no matter how precise the procedures, will share the same uncertainty of location as their reference points. The accuracy of location of property boundaries in turn depends on the accuracy of location of the monuments marking the boundaries. If the accuracy of location of property boundaries and property surveys is to improve, then the accuracy of location of the reference points -- the control points for the cadastral system -- must be quantifiable. Thus, there will need to be a program to tie these points to a specified degree of accuracy to the State Plane Coordinate system.

What degree of accuracy is appropriate for Multnomah County's cadastral mapping system?

> With respect to accuracy, the determining factor will be the extent to which the control survey stations are to serve multiple purposes. ...[I]f the integration of the positional data is to be done graphically, a relatively low order of accuracy will be required for the horzontal control network, such as that attendant to the federal classification of third-order, class II (Federal Geodetic Control Committee, 1978). If, however, the data are to be integrated numerically and if the control surveys are to have multiple applications, minimum accuracies at least attendant to the federal classification of third-order, class I, or second-order, class II, should be met [NRC, 1983].

Following these recommendations, then, the goal of the program should be to meet the higher requirements. Should this be seen as an eventual goal, or one which must be completed before any other step in the program? If the multipurpose cadastre had the capability to treat locations of objects in non-base layers as derived values, mapping of survey and property information could proceed in advance of completion of an extensive field survey program. As we noted in the previous chapter, however, such a system is unlikely to be implemented as a first step, due to the untried nature of the technology involved. An interim system, in which locations could be upgraded only through operator intervention, would be optimally successful only if control points were accurately located first. If it were determined that the interim system should have its cadastral layer compiled by digitizing assessor maps and fitting them to control, then the lower order of accuracy (third-order, class II) wuld be appropriate. It is more likely, however, that the cadastral layer will be reconstructed from source data. This likelihood, combined with the probability that monuments will be used for other survey purposes in addition to property location, implies a need for a higher order of accuracy -- third-order, class I, or second-order, class II.

Property and engineering survey layer

Related to, but separate from the layer of control point information, the layer of property and engineering survey data in the county cadastre has two important purposes. First, it serves as a framework for most of the cadastral layer. Since a high proportion of surveys made in the county actually locate property monuments, the relationship between the two layers is direct. Other layers in any future land-information system will also undoubtedly reference objects in this layer for their location. Secondly, a graphic file of property and engineering surveys should serve as a valuable resource for surveyors and engineers working in the county. Using such a file should enable them to quickly locate documents relating to surveys and to determine locations of reference monuments.

There are both institutional and technical arguments for separating the survey layer from the control and from the cadastral layer. In the case of the control layer vis-à-vis the survey layer, the argument is technical: the survey layer will be much larger than the control layer and more frequently edited. Since the control will be accessed for locating objects in any of the other layers, it should contain a minimum of unnecessary points.

The reason for separating the survey and cadastral layers is more purely institutional: the two types of information are managed by different agencies. Many land parcels are not located by survey, and many survey measurements do not relate to boundaries.

A few interesting implications fall out from this separation. One is that the county surveyor will have to take an active rôle in planning and maintaining a multipurpose cadastre if the goal of making cadastral information more accurate is to be realized. Another is that, in the absence of a system technology that would permit automatic updating of location of cadastral objects, a procedure must be set up for notifying the assessor map maintenance function whenever a survey monument location is changed -- essentially, whenever a new survey is filed.

Institutional links to the surveying community

Implementing the goal of improving the accuracy of cadastral maps in Multnomah County will require much closer cooperation between the surveying community and the assessor than has existed heretofore. Maintaining a file of the State Plane Grid location of PLSS corners, DLC corners, and other monumented locations; maintaining monuments, re-establishing monuments, and increasing the precision of location of monuments; and maintaining a graphic layer of property surveys are all tasks which might appropriately be undertaken by the county surveyor's office. The question might well be whether that office feels ready to take on the tasks. What benefits exist for the surveyor's office?

Some possible ones are: improved ability to respond to private property and engineering surveyor's needs; the ablility to display, plot, and prepare reports on the various surveys and their spatial relationships to each other; the ability to use more sophisticated and accurate adjustment algorithms to improve the overall quality of control monument location; more graphic, rapidly accessible, and timely information on the status and condition of control survey monuments.

Chapter 7

RECOMMENDATIONS

We here present recommendations in five general areas of activity: first, building the ground reference layer -- the control survey monumentation layer; second, increasing the availability of information on survey control and large-scale mapping; third, creating a layer of property and engineering survey data; fourth, building the cadastral layer; finally, for sharing data and expanding system capabilities. Although the presentation implies a chronological flow, we would like to emphasize that certain activities in each of the general areas will need to be addressed early on in the process of building the overall system if they are to be completed in time for other parts of the system to build on them. In addition, it is important to note that most areas mentioned relate to activities that ultimately are the responsibility of other agencies than the county assessor. Coordination of these activities shall have to take place at a higher level within the County.

Coordination is, in fact, the byword under the assumption that (following the system concept presented in chapter 4) the multipurpose cadastre will be implemented as a distributed information system, with most of the different agencies maintaining their layers of data on their own machines and sharing data either by media transfer or data communications.

The control layer

- **The County should build an information system for geodetic control point data on a common grid (State Plane Coordinate System on NAD83) to serve as a basis for registration of all other data layers in the multipurpose cadastre.**

This system would logically be the responsibility of the County Surveyor. It should contain data about all permanently monumented points tied into the State Plane Coordinate system by any surveying organization operating in the County. The system should contain the reference name or number and the State Plane Coordinate values of the monuments, particulars of the monuments' appearance, directions to recover, establishing agency, and degree of accuracy of the establishing survey.

- **The County Surveyor should monument section corners, quarter corners, centers of sections, Donation Land Claim corners, and other important property reference points.**

These monuments should be tied in to third-order, class I or second-order, class II accuracy to the State Plane Coordinate System (NAD83). They should be included in the information system discussed above.

The main effort here would probably begin with going through previous observations tying points to NGS monuments and adjusting them, using the procedures outlined in chapter 6, both to derive NAD83 State Plane coordinates and to be able to determine the accuracy of the old observations. These points should be adjusted, or, where necessary, reobserved to bring the network to the recommended accuracy while working ahead of the cadastral mapping. As was noted above in chapter 6, a relatively modest monumentation program would probably cover all important points in the county in a few years. Once all points were monumented, a maintenance programs should be set up.

Improving survey practice and increasing availability of survey and large-scale mapping data

- **A joint educational and information sharing program should be set up between government agencies and local professional organizations to actively involve surveyors practicing in the county in developing and adding to the geodetic control information system, in sharing information, and developing standards, guidelines, and ordinances to improve the quality of survey practice in the county.**

Involvement of local surveyors is essential to extending control monumentation, tying in points to the State Plane system, and developing a clientele for the geodetic control information system. Their support and expertise will also be necessary in extending the system and providing a basis for the cadastral segment of the multipurpose cadastre.

- **County ordinances should be established requiring that new surveys filed with the County be tied to monuments having State Plane coordinates.**

The procedures ensuring that ties be made to a known order of accuracy should be explicitly set out or referenced in the ordinances, and should follow the National Geodetic Control Committee guidelines. It is likely that a special "cadastral" accuracy requirement would be set up. The order of accuracy involved for the tie need not be second-order or even third-order. In any case, the method of determining the accuracy of the tie should follow the procedures discussed in chapter 6. Requirements would be in force only if monuments were within a reasonable distance of the survey in question. The ordinances should also require the filing of copies of the field notes for the survey in addition to the presently required plat or drawing. Permanently monumented new points tied in this manner to the State Plane coordinate system could be added to the geodetic control monument information system.

- **An agency should be designated to collect and serve as an information source for large-scale topographic and planimetric line maps and orthophotography for the county.**

Perhaps this is a job for the County Surveyor. This map collection would be a valuable resource for many agencies, but in the present context it is seen as a source for eventual compilation of the cadastral layer, in conjunction with other data. Large-scale maps and orthophotos contain a class of data often referenced by cadastral objects for location: "natural boundaries", which are often not surveyed.

The property and engineering survey layer

- **A survey information system should be built, comprising the digital layer of property and engineering surveys filed with the County Surveyor. This layer would be referenced to the geodetic control layer, and would form an extension of the control point information system discussed above.**

At this point, we don't know who should build this layer. The two obvious candidates are the County Surveyor and the State Department of Revenue. Arguments in favor of the County Surveyor doing it are: control over format and procedures, familiarity with local surveying conditions, and availability of source data. Arguments against are: lack of experience in digital mapping and requirement for larger data input resources (equipment and personnel) than for simple maintenance. Arguments for the Department of Revenue are: duplicates usual procedure when reconstructing cadastral maps, specialists in constructing digital maps. The arguments against are the converse of those in favor of the County Surveyor doing it.

The Cadastral Layer

- **The County Assessor and State Department of Revenue should determine which of the combinations discussed in chapter 5, above, of registration layer content, cadastral**

layer compilation method, and description data capture best meets their goals.

This determination will be a wiser one if the agencies involved keep in mind the probable direction and timespan of technological development. First of all, there are convincing arguments for reconstructing the cadastral layer at this time: the maps are overdue for it and it can be done effectively by DOR. If a new technology should arise at a later date which can capture and make use of the locational rules, objects, and parameters, the existing map layer could be transferred as an image to the new system and the attachment of locational rules, reference objects, and parameters could proceed on an incremental basis. Thus, there would be no need to totally reconstruct the cadastral layer again after it had been done for the first digital conversion.

The real question is, should an attempt be made to capture the locational rules, reference objects, and parameters at this time for eventual inclusion into a future data base which can make use of them? We are less sure of the answer to this question, since it essentially depends on the willingness of system vendors or DOR to develop such a capability.

- **The County Assessor should undertake a functional analysis of current operations on map data to determine the entities and operations involved in cadastral mapping, develop a data dictionary, and outline a prototype database schema.**

This schema should have the goal of answering the questions posed in White [1984] in the affirmative.

Sharing data

- **The County should establish a user group and a technical support group to coordinate and facilitate digital cartographic data sharing among public and private agencies using County cadastral map data.**

The user group should consist of high-level management or their direct representatives, and should meet on a regular basis. This would be a coordinating body. Each agency is, ultimately, independent. The technical support group should be responsible to the user group, keeping it informed of the status of the system as a whole, working with individual agencies in developing ways to make use of the various layers of the mapping system (with the aim of making it possible for any agency to make its regularly-used products on its own), and investigating ways to extend and enhance the system (by, for instance, establishing new linkages between digital cartographic data bases or geo-related data bases.)

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Appendices

Appendix A

ORGANIZATIONS CONTACTED
AND
QUESTIONS ASKED
OF ASSESSOR MAP USERS

Organizations

Multnomah County

Department of Environmental Services	
Engineering	Dennis Fonz Ike Azar
Planning	Bob Hall Bruce Batson
Sheriff Department	Chuck Fessler
Elections Department	Vicki Ervin Al Robert Jeff Klien

City of Portland

Office of Transportation	Dick Stewart Ron Edson
Water Bureau	Jim Michaelson Dan Conner Bill Wright
Department of Environmental Services	Jane Whitcher
Bureau of Emergency Communications	Kathy Black

Bureau of Planning	James Throckmorton Colleen Acre Marie Williams Laura Paulson
Fire Bureau	Al Allaway
Parks Bureau	John Sewell
City Auditor	Edna Cervera
Office of Fiscal Administration	Chuck Olson
City of Gresham	Jeff Davis
City of Troutdale	Greg Wilder
Rockwood Water District	Mike Baker Chuck Fisher
Portland Public Schools	Porter Sexton
Port of Portland	Don Conwell Sebastian Degens
Tri-Met	Diana Anderson Marcia Monadjemi
Metro	Dick Bolen
Oregon Department of Transportation	
Engineering	Jim McClure Kurt Duvall

Right of Way	Roger Jamer
Utilities	Dick Fleming
Bonneville Power Administration	Bill Young
Pacific Power and Light	Herb Nelson Linden Brendt Don Shores Bob Barber
Portland General Electric	Ed Sipp John Chapman
Northwest Natural Gas	Doug Tiljner Mike Osterman
Wilsey and Ham	Linda Conway
David Smith and Associates	David Smith
Spencer Gross	George Gross
Chase, Jones and Associates	Jim Chase
Coffman-Pettijohn Engineering	Art Gibson
CH_2M Hill	Doug Gaibler
Stewart Title	Allen Slipher

Ticor Title	Mitch Stevens Todd Walker
First America Title	Ron Richardson Al Turner
Safeco Title	Patty Faulk

Note: this list does not necessarily include all of the individuals talked to in each organization nor all of the organizations originally contacted.

Questions

Interview number
Type of user

Agency or company; Date; Phone

Section I: Use of assessor maps

1) Person(s) interviewed; Name; Position
2) What general type of work is performed by the person(s) interviewed?
3) What types of tasks do you currently undertake which require the use of assessor maps? Why do you use assessor maps as opposed to other types of maps?
4) What information do you obtain from the assessor maps?
5) What steps, if any, do you have to go through to make the information usable for your purposes? Do you have to manipulate, supplement or convert it in some fashion?
6) Does this process involve a large number of person-hours: estimate?
7) What types of products result from this process: reports, maps, legal descriptions, etc.?
8) Do the current scales of assessor maps meet your mapping needs? What map scales would better meet your needs?
9) Does the current schedule of updating the assessor maps meet your needs? What schedule would be better for you?

Section II: Data requirements

10) What data files, map layers or map content would be necessary for a computerized assessor mapping system to be usable in the work you currently undertake using assessor maps? For future work?

11) What level of locational accuracy would you require to make a computerized assessor mapping system usable for your needs?

12) How often would you need to have updates to the computerized mapping system?

13) Would your organization be willing to provide data for a map layer of such a system? What would you see as the problems of a system where the data was provided by different sources?

14) How would the existence of such a system affect the tasks you currently perform?

15) What additional tasks would you be able to undertake, using such a system, that you are currently unable to undertake?

16) What type of control data and/or large scale maps does your agency have? Could we review them later and who should we contact to do this?

About UAM, Inc.

UAM, Inc., formerly United Aerial Mapping, is a wholly-owned subsidiary of Stewart Title Company. Since its founding in 1957 as a photogrammetric engineering and mapping company, UAM has shown progressive growth in both capabilities and technical innovation and now provides its clients with a complete range of services including the following:

- Aerial Photography
- Topographic and Planimetric Mapping
- Terrestrial Photogrammetry
- Stereo Digitizing
- Digital Cartography
- Geodetic and Topographic Surveying
- Photographic Reproduction
- Data Processing
- Systems Analysis and Design
- Digital Image Processing

As a consequence of the company's technical and productive growth, UAM has been rated as one of the top photogrammetric firms in the United States in both production capacity and technical ability.

The company has consistently supported its clients on a national basis for over 28 years and has expanded its services to a world-wide capability in 1980. Since then UAM has completed projects in Central America, West Africa and the Middle East. We are currently undertaking overseas projects, and we welcome the opportunity to provide our services to your organization wherever the project is located.

UAM operates from two major U.S.-based facilities and several major international field locations. The executive offices and production facility are headquartered at 5411 Jackwood Drive, San Antonio, Texas 78238. A sales office is located at 2200 West Loop South, Houston, Texas 77027. Representatives are also located in London, England and Cairo, Egypt.

Our staff and facilities are able to complete projects, regardless of size, within the most rigorous of delivery schedules. The company has a proud reputation of completing projects on schedule, within budget, and with impeccable technical quality as a result of our professional dedication and effective management procedures.

Our multi-disciplined and cross-trained staff channels its extensive experience into a pragmatic approach to the solution of a client's problems. Many of our staff members have over 20 years' professional experience and maintain their skills and knowledge of advanced techniques through continuing formal education and practical work in implementing new methodologies.

UAM has an enviable blend of equipment, facilities, and staff members who are dedicated to the exploitation of equipment resources to their fullest production capacity and technical capability in order to meet the specialized needs of a client's project. This is in accord with our basic management philosophy, which is project-oriented and recognizes that the project needs are our most important concern.

In keeping with this concept, UAM has continually adopted the latest photogrammetric techniques and equipment in order to provide unexcelled photogrammetric engineering services. At UAM's production facility in San Antonio, photogrammetric equipment is interfaced to powerful computer systems - a network of three VAX 11/780's and one VAX 11/750. These provide an unsurpassed data processing and digital mapping potential in conjunction with our Wild Aviomap AM and four fully encoded Wild B-8 Stereoplotters.

Our approach to digital mapping and stereo digital data collection has crystallized during the past few years to a concept which mandates that digital data collection and graphic manipulation should be independent of any specific interactive graphic vendor's hardware/software system, but that the digital data should be capable of being transferred to an interactive graphic system as a neutral data base. This approach permits UAM to retain the flexibility that is essential to the highly technological field of computerized mapping.

The system installed at UAM's production facility in San Antonio provides on-line connection of photogrammetric equipment to the host computer system. The integration of stereoplotters to the computer system goes far beyond the interfacing of digital encoders. Special consideration has been given to the compilation of a three-dimensional stereo model supported by software which has been designed on the basis of user and operator specifications. Continual enhancement of software and operating procedures provides UAM with a powerful and flexible capability to produce many different kinds of maps, map overlays and graphic displays to meet our clients' needs. Below is a partial list of the software applications currently being employed by UAM.

- Engineering Feasibility and Design Studies
- Topographic or Terrain Modeling
- Plant Site Location Studies
- Excavation or Pit Mining Studies
- Oil and Gas Exploration Analysis
- Land Use Planning and Resource Analysis Studies
- Ownership Mapping/Tax Mapping/Utility Mapping
- Environmental/Forestry/Agricultural Development Studies

UAM has a completely equipped and automated photographic laboratory in San Antonio, Texas, to provide all photographic support services in-house. Wild B-8 Stereoplotters are used in all line mapping and fully analytical aerotriangulation is performed in-house at the San Antonio production facility.

This equipment enables UAM to provide the most sophisticated aerial mapping capability in the United States. A principal advantage of this state-of-the-art installation is shorter delivery times from date of aerial photography to the finished product. UAM provides all photogrammetric services from aerial photography and field surveys through stereoscopic compilation, scribing and final reprographics.

Beyond the major advances in technology, we continually incorporate into our operational process the latest improvements in equipment and techniques. Our flight technicians, cameramen, engineers, lab specialists and professional cartographers are involved in a continual program of operational enhancements. These enhancements are directly translated into dramatic cost savings for our clients.

These savings include enhancements in the use of aerial photography for analytical photogrammetry and orthophotography as well as numerous cost effective applications on projects requiring tax maps, zoning plats, traffic studies, defense logistics, pipeline route selection and construction, airport construction, industrial development, watershed projects, river and harbor evaluations, dam sites, farm control, highway projects, energy development, forestry programs, conservation studies and many more. The scope of these various uses takes on added impact when it is accepted that each application has its unique and individual project requirements.

Our reputation as one of the industry leaders in the exacting field of aerial and terrestrial photogrammetry and property ownership mapping is based on a solid foundation of satisfied customers ranging from consulting engineers and architects to local and federal government agencies throughout the United States and various foreign countries.

INTRODUCTION TO
LANDATA, INC.

The purpose of Landata is to economically automate Stewart Title and the title insurance industry. To date, we have eleven offices supplying automation through over 225 terminals.

The year of 1984 was one of expansion and completion. During the last year, we have opened up six subsidiaries, and we now have offices in: Austin, Dallas, Denver, Houston,Kansas City, Los Angeles, Portland, San Antonio, Tampa, and West Palm Beach. During the year, the Personal Computer was added to our product line, and 51 Professional 350 systems were placed into operation, additionally, 14 VAX machines were installed.

Also, 1984 saw the completion of the tied "AIM" system. It is now installed in Houston, San Antonio, Austin, West Palm Beach, Denver, and Portland, allowing these offices to maximize the benefits of automation.

The direction of 1985 will be to strengthen our automation base through the profitability of the current ten subsidiaries. Research and development will be continued to increase the capabilities of the VAX machines in the field, by the use of terminal servers and micros.

Sites for additional Landata offices will be carefully selected and brought out of the ground with the "Walk-Trot-Run-Philosophy." Automation will be started through long lines back to an existing subsidiary, until twelve to fifteen terminals can be supported.

The Escrow through the banks program will continue to be pursued. This concept will be expanded to include the PRO 350 as a product available under this program.

The PRO 350 will be an integral part of our 1985 plans. This system is the stepping stone to larger automation. Once a site has grown to a capacity of two PRO 350 systems, then, the next step is to utilize a VAX system. With a VAX system installed, the PRO can be utilized as a terminal in a branch location. Expanded use of the PRO in branch locations will allow the use of dial-up modems instead of dedicated phone lines. This will result in considerable cost savings while increasing your ability of being independent of large VAX operations.

Landata's marketing is coordinated along the Stewart Title Region and District managers' lines. Each LDI subsidiary is responsible for coordinating their marketing targets with the Stewart Title Company managers. The formation of a six-month plan will be developed, with each manager, on all current and future clients. From these six-month plans, LDI will increase its communication and direction into the marketplace.

OUR SERVICES

At LANDATA - GOVERNMENT SYSTEMS we provide various forms of computer system support for public and private sector clients. Included in these services are:

- o COMPUTER TIME SHARING

  We provide computer time sharing services.

  Presently LANDATA supports 275 time sharing terminals on our DEC VAX computers. We have four computers located in Houston, Texas two in San Antonio, Texas and one in West Palm Beach, Florida; Dallas, Texas; Denver, Colorado; Phoenix, Arizona; and Los Angeles, California.

- o COMPUTER SYSTEM SALES

  We sell computer hardware; we are a DEC Original Equipment Manufacturer's (OEM) representative for the VAX and Professional 350 series.

- o SYSTEM ANALYSIS

  We help people plan for automation and design new applications.

  We can provide on-site analysis of existing operations and prepare specifications which guide the design of computer applications.

- o STANDARD APPLICATION PACKAGES

  We sell and install computer software.

  LANDATA - GOVERNMENT SYSTEMS has developed a number of software application packages which are designed to meet the needs of specific users.

- o CUSTOM PROGRAMMING

  We design special computer programs for special needs.

  While our normal scope of business is to provide and maintain our own software systems for county governments, LANDATA - GOVERNMENTAL SYSTEMS will also provide contract programming services. Our staff has had experience on a wide range of computers and in a number of programming languages.

Appendix C

DATA SET DEFINITION
MULTNOMAH COUNTY PLANNING

index	data element name	size/type	natural name
L0020	access	x(25)	access-to-property
L0041	actions	group	actions
L0040	action/case history	group	action-case-hist
D0054	addition name	x(24)	add-name
L0049	agency	x(06)	agency
L0004	air photo number	9(06)	air-photo
L0052	applicant	x(65)	applicant-name
L0061	assessor's data	group	assess-data
D0050	block number	x(07)	blk-no
L0046	cases	group	cases-gp
L0002	cases	x(01)	cases
D0058	census tract	x(06)	cen-tract
L0006	centroid (x)	9(07)	centroid-x
L0007	centroid (y)	9(07)	centroid-y
L0043	created from	x(10)	created-from
L0048	date received	x(06)	date-received
L0027	elementary school	x(20)	elementary-school
L0047	file number	x(09)	file-number
L0024	fire district	x(20)	fire-district
L0017	flood plain	x(01)	flood-plain
L0018	geologic hazards	x(01)	geologic-hazards
L0011	historical/cultural	x(01)	historical-cultural
L0028	junior high school	x(20)	jr-high-school
L0014	land use code	n(04)	land-use-code
L0014a	land use category	x(01)	land-use-category
L0045	last county zone(s)	x(19)	last-county-zones
L0051	location	x(15)	location
D0049	lot number	x(07)	lot-no
L0025	lighting district	x(20)	lighting-district
D0028	mailing data	group	mail-data
D0056	map number	x(06)	map-no
D0256	market value - improvements	s9(10)	mkt-val-imps
D0245	market value - land	s9(10)	mkt-val-land
D?	market value - total	?	?

L0010	neighborhood	x(16)	neighborhood-code
D0218	number of living units	s9(03)	no-living-units
D0017	owners name line 1	x(28)	own-name-1
D0018	owners name line 2	x(28)	own-name-2
D0205	parcel area type	x(01)	parcel-area-type
D0206	parcel length	s9(03)	parcel-length
D0203	parcel size (ps)	group	parcel-size
D0204	parcel width	s9(05)v99	parcel-width
L0062	permits	group	permits-gp
L0060	permits and violations	group	permits-viol
L0008	plan designation	x(03)	plan-designations
D0202	ratio code (rc)	x(03)	ratio-code
L0026	school district	x(20)	school-dist
L0002	sectional zoning map number	x(04)	sec-zone-map
L0029	senior high school	x(20)	high-school
L0019	services	group	services
L0022	sewer pipe	9(03)	sewer-pipe-diameter
L0022a	sewer district	x(20)	sewer-district
L0006	site data	group	site-data
D0042	situs address - city	x(22)	sit-addr-city
D0041	situs address - street	x(28)	sit-addr-street
D0043	situs address - zip code	x(09)	sit-addr-zip
D0040	situs data	group	situs-data
L0016	slope	9(03)	slope
L0015	soil symbol	x(03)	soil-symbol
L0050	status	x(02)	status
L0050a	status-date	x(06)	status-date
L0023	storm sewer pipe	9(03)	storm-pipe-diameter
D0029	taxpayer name line 1	x(28)	payer-name-1
D0030	taxpayer name line 2	x(28)	payer-name-2
D0031	taxpayer address line 1	x(28)	payer-addr-1
D0032	taxpayer address line 2	x(28)	payer-addr-2
D0033	taxpayer zip code	x(09)	payer-zip-code
L0005	topographic map number	9(04)	topo-map
L0012	transportation zone	9(04)	transportation-zone
L0013	urban growth boundary	x(01)	urban-growth-boundary
L0014a	use code	x(01)	use-code
L0063	violations	x(160)	violations
L0021	water pipe	9(03)	water-pipe-diameter
L0021a	water district	x(20)	water-district
D0044	year annexed	9(04)	year-annexed
D0216	year built (yb)	s9(04)	year-built

L0041	year created	9(04)	yr-created
L0009	zone district(s)	x(06)	zone-districts

Appendix D

OPERATIONAL QUESTIONS FROM "TECHNICAL REQUIREMENTS AND STANDARDS FOR A MULTIPURPOSE GEOGRAPHIC DATA SYSTEM" [WHITE, 1984]

Topological Questions

1. What 0-,1-, and 2-dimensional elements does the map comprise? In a geographic data system, this question would be answered by a list of 2-cells, 1-cells, and 0-cells.

2. Which 2-cells cobound a particular 1-cell? There will always be exactly two 2-cells for each 1-cell in the two-dimensional case.

3. Which 0-cells terminate particular 1-cells? There will always be two endpoints for each 1-cell. This question is the *dual* of question 2, which means that this question is symmetrical to question 2 in a certain mathematecal sense. As for 2-cells, there are always two bounding 0-cells for each 1-cell.

4. For a particular 0-cell, which 1-cells are incident? That is, which lines all come together at a particular 0-cell?

5. For a particular 2-cell, which 1-cells are incident?

Metrical Questions

1. What is the location of a particular 0-cell? The answer is usually expressed in *x-y-z* coordinates, giving the location of the 0-cell in three-dimensional space. The particular kind of coordinates (geodetic, Universal Transverse Mercator, or whatever) is irrelevant here. That choice is of concern in data exchange and in technical surveying matters, but is not a geometrical question. Descriptive information regarding the precison of the coordinates, ties to the local network of monuments, and other relevant survey notes should also be recorded and associated with 0-cells.
2. What is the shape of a particular 1-cell? The answer can be a stream of *x-y-z* coordinates, piecewise arcs of circles and line segments or any parametric representation. Applications will determine the details of how shapes are specified. Again relevant survey notes and precision data shold be recorded and associated with 1-cells.

3. What is the shape of a particular 2-cell in 3-dimensional space? On maps, shape is usually portrayed by closed contours, shaded relief, and sometimes by cross-sections

or profiles. In digital maps, the 2-cell shape data are usually stored in a form close to the output form of the data capture equipment. For example, some stereo photo viewers produce contour lines traced by an operator, which are then stored directly. Many digital terrain models compute contour lines from the locations of points in a triangulated net but do not store contours. For our purposes, answers are required; details of storage are not specified.

Questions Regarding Consistency

1. Is the surface smooth and completely covered? This question is answered by asking a simple question for each 0-cell in the data base. If one imagines each 0-cell to be at the center of an umbrella with the incident 1-cells being the struts and the incident 2-cells being the webbing, the question is whether each 0-cell is covered by such an umbrella or not. It might not be covered in case a 2-cell or 1-cell is missing or the relation of the 1-cells to the 2-cells is incorrectly specified. This simple question, when answered negatively, isolates inconsistences in the geographic description that otherwise would be nearly impossible to find.

2. Is every 2-cell bounded by a set of 1-circuits? Although it may not be apparent, this question is the dual of question 1 and serves the same purpose.

3. Are the metrical descriptions consistent with the topological descriptions? Do any lines intersect themselves or other lines or 2-cells? Do any 2-cells self-intersect or intersect with other 2-cells? There should be no intersections. Every point of contact is specified in the answers to the topological questions. This question can be answered for the entire map by asking it for any closed neighborhood of each 0-cell that is large enough to include the 2-cells incident to the 0-cell.

Editing and Updating Questions

1. Are the topological and metrical questions still answerable after altering the data? How long after (are there background batch processes, for example)?

2. If the consistency questions are all answered affimatively for every cell in the closed neighborhood of a change, are they still answered affimatively after the change? This question is about the system rather than of the system and must be answered generally.

Error Detection and Control Questions

1. What 0-cells are not covered by an open umbrella (if any)?

2. What 2-cells are not bounded (if any)?

3. What intersections exist (if any)?

Geographical Questions

1. For any two regions A and B, does A = B? Unique identification is necessary to avoid ambiguity. Some cities and counties are co-extensive, for example, San Francisco: San Francisco county = city of San Francisco.

2. What regions does a given region cover?

3. What regions cover a given region?

4. What is the join of two regions?

5. What is the meet of two regions?

Questions Regarding the Connections between Geometry and Geography

6a. For a particular region, what 2-cells (listed in the geometrical portion) are included?

6b. For a particular 2-cell, what regions include it?

7a. For a particular linear feature, what 1-cells are included?

7b. For a particular 1-cell, what features, such as street, river, or ridge line, include it?

8a. For a particular set of points (monuments, named locations, and so forth) what 0-cells are included?

8b. For a particular 0-cell, what set of points include it?

Questions Relating to Accuracy

1. What is the provenance of specific data (survey, map series, aerial photos, and so forth)? How is the existence of a particular feature known?

2. What is the precision of relevant measurements?

3. What ties exist to other sets of data, for example, the geodetic net?

Software Requirements

1. Software must be conservatively extendible, that is, new purposes must be met with new sofware built on the existing foundation but without greatly altering existing software.

2. The software must be maintainable and alterable to accomodate improved or new hardware and new software.

3. The software must be reliable. Recovery from errors must be possible and errors must be detectable.

Conclusion

By considering the underlying theoretical basis for a multipurpose land data system, we have presented technical standards in the form of questions that must be answerable. These standards are quite general in nature and apply to any multipurpose land data system. Just as the theory provides a foundation for a particular system, these standards are fundamental to a more detailed specification.

Appendix E

NOTES ON MODEL GEOGRAPHIC BASE FILE SCHEMA

Peter Van Demark, March 1985

Introduction

This schema is an attempt to abstract many of the current geographical base file concepts into a diagram that shows the records, fields, indicies, and relations. Indicies are used both for preserving record uniqueness and for allowing rapid access to records, especially for relations.

Records

There are four types of records:

1. Topological, storing the location of 0-cells, the shape of 1- and 2-cells, and maintenance information. The location of a 0-cell is stored twice for convenience, once as normal X, Y, and Z coordinates (e.g. longitude, latitude and deviation from speroid), and once with the X and Y coordinates combined in such a way as to allow rapid geographical searches for nearby 0-cells (e.g. using a Peano key, where the bits are alternately taken from the X and Y coordinates). The shape of a 1-cell, if it exists, is either a series of locations (jagged shape) or a series of parameters (smooth shape). The shape of a 2-cell is a series of parameters that describe the undulations of the surface within the 2-cell. The shape type could be the sign of the ID, as there need only be types for 1- and 2-cells, and the ID's can always be positive. Shape data could be handled by storing the coordinates or parameters in a separate "heap" file and by having the Shape record point to the start of the list; the Shape record as shown would be a "virtual" record. The maintenance information is for tracking topological changes to the file, by indicating the record creation date, the date of last update, the editor and whether the record is marked for deletion. With this information seperate copies of the same geographic base file can be kept topologically consistent.

2. Relation, storing relations between records. All records have a unique index, comprised [sic] of one or more fields. There are 1:1 relations where the index has only one field, or when there is a Type field before an ID field (useful for reducing the number of files). There are 1:n relations where the index has a field after the ID field; a partial key match will access all related records.

3. Common attribute, storing attributes of 0-, 1- or 2-cells that will be a regular part of a geographic base file. Two are defined, and each has Types; these could end in "0" for 0-cells, "1" for 1-cells and "2" for 2-cells. Each also has Sequence numbers in their relational files; the first sequence number can indicate the primary attribute record. Name records store the external name of a cell, e.g. the street name of a 1-cell (and all alternate names). The NameKey is a Soundex or other key for address matching or other applications. The CenterX and CenterY fields for Two-Names are a convenience for storing a location for plotting the 2-cell name. Group records store information about the groups to which cells belong, e.g. the next larger unit in a hierarchy of 2-cells. Lattices could be handled using the GroupType and InGroup's [sic], the latter indicating the next larger grouping in the hierarchy or more complex lattice. Some GroupTypes would only point to other Group records, while GroupTypes would point to Group relation files and thence to cells. The GroupName can give the external name for a group, e.g. an area name.

4. Additional attribute, storing other attributes for 0-, 1- and/or 2-cells. These could include the type of traffic control at a 0-cell, the address range(s) along the right or left side of a 1-cell, or the 1980 population of a 2-cell. It is these records that move the data base from a strict geographic base file to the basis for a geographic information system.

Handling non-topological cartographical features

If a cell is created, the other-dimension features that it (co)bounds must also be cells; this is monitored by the axioms. But a feature need not be a cell. A Zero record not referenced in One-Zero records is just a point, such as a test hole. A One record that does not start and end at a 0-cell is a line segment (two shape points), string (more than two shape points) or an arc (parametric curve). A Two record not referenced in One-Two record is a polygon bounded by one or more strings or arcs with closure; the polygon can be defined with Shape records. (The terms used here are based on Moellering, Harold, Ed., 1985, Digital Cartographic Data Standards: An Interim Proposed Standard, Issues in Digital Cartographic Standards, Report No. 4, Columbus, Ohio.)

Axioms

1. Every 1-cell is bounded by a pair of (not necessarily distinct) oppositely oriented 0-cells.

2. Every 1-cell is cobounded by a pair of (not necessarily distinct) oppositely oriented 2-cells.

3. Every 2-cell is bounded by one or more simple cyclical chains of alternating 1- and 0-cells.

4. Every 0-cell is cobounded by a simple cyclical chain of alternating 1- and 2-cells, with the angle of the 1-cells monotonicallly increasing or decreasing around the chain.

5. There are no intersections.

Appendix F

LARGE SCALE MAPPING AND CONTROL POINT MONUMENTATION IN MULTNOMAH COUNTY

This Appendix is supplemental to comments in the first portion of the report. Many large-scale planimetric and topographic line maps and orthophotos are the property of private contractors (mostly photogrammetrists) and are not filed with government agencies, although they would probably be available for use by them. This appendix discusses map series covering large areas held by utilities or local government agencies, and monumented survey points tied to the State Plane coordinate system.

First, we should mention a twenty-year old report done one of the last times around when people were considering computerizing land records and property maps. This is the "Index to Property Monuments Tied to the State Plane Coordinate System" prepared by the Metropolitan Planning Commission in 1965. It contains data on over 1,260 property monuments in Multnomah, Clackamas, and Washington counties, and is available through the City of Portland Archives.

Control points

The Banfield Light Rail project has installed permanent monuments along the eastside project route, from Gresham to downtown Portland along Burnside and the Banfield Freeway. The data is in computer form, on State Plane coordinates, and is "third-order or better".

Port of Portland has installed approximately third-order 200 monumented points at Port installations throughout the county, including the Troutdale and Portland airports, Rivergate, Swan Island and Mocks Bottom, and the terminal areas. The data are in hard-copy form, on State Plane coordinates.

Oregon State Department of Transportation has "several thousand" monumented points along the rights of way of state and federal highways. Most of these are not tied to State Plane coordinates. Their accuracy of location is highly variable. More recently completed projects are tied to the State Plane Coordinate system and are fairly accurately located. The data exists in hard-copy form, and is on file with the County Surveyor.

The City of Portland has a computerized file of "several thousand" permanently and temporarily monumented points throughout the City. Individual points are located in terms of various local grids; some points are located on the State Plane system.

Description of accuracy of location is qualitative only; the order of survey accuracy is not recorded.

Multnomah County has permanently monumented approximately 80% of the defined section corners in the county. Most of the section corners and quarter section corners in the area between 82nd Avenue and Gresham have been tied to the State Plane system, although the order of survey accuracy is not known. There is no consolidated list of points tied to the State Plane system. What data exist are in hard copy.

Large-scale maps

In addition to the maps prepared by the City of Portland Department of Transportlation, mentioned in chapter 1, a series of 1" = 100' topographic maps was prepared in the late 1970s by Spencer Gross covering most of the urbanized area. No compliance statement (with National Mapping Accuracy Standards) appears on the legend, but they were apparently accepted by the City.

Multnomah County has topographic mapping, at 1" = 100', of the area between 82nd Avenue and Gresham. This series also has not been subjected to formal compliance checks.

As mentioned in chapter 1, Portland General Electric has a digital layer of planimetric data covering the metropolitan area. Accuracy of points in this layer is on the order of ±10 feet.

The city of Troutdale has a recently compiled 1" = 100' topographic map series covering their territory.

The project strip maps of the Oregon State Department of Transportation often contain some planimetric data along the right of way. These maps are usually drawn to a scale of 1" = 100', with some at 1" = 50'. They are on file with the County Surveyor.

And the Tri-Met Light Rail Project strip maps also contain planimetric data. They are also drawn to 1" = 100' or 1" = 50'.