ALTERNATIVE ROUTES TO A MULTIPURPOSE CADASTRE: MERGING INSTITUTIONAL AND TECHNICAL REASONING

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ABSTRACT

The National Research Council report "Procedures and Standards for a Multipurpose Cadastre" sets admirable goals, but may not provide the most workable means to the ends. In the search for modernization, technical and institutional reasoning should be merged. Institutions can act as barriers to modernization, but they can also act in a more positive manner, shaping the technical needs. This paper considers three topics related to construction of a multipurpose cadastre: incrementalism, basic unit, and compilation procedures. In each case, we present some dilemmas that deserve further interdisciplinary discussion.

THE MULTIPURPOSE CADASTRE

To date, the development of automated spatial information systems has progressed dramatically but with limited planning and almost no sense of vision. Systems are purchased by agencies and companies to assist in their preestablished roles. This behavior is perfectly rational, but only in the short term.

In contrast to the general drift of computerizing current functions, there is a growing interest tied to the term "multipurpose cadastre". Starting from a group of committed professionals, activity has expanded through three reports of the National Research Council (occasionally abbreviated as NRC below). The Committee on Geodesy Panel on a Multipurpose Cadastre first published Need for a Multipurpose Cadastre (NRC, 1980). This panel, somewhat reconstituted, continued with Procedures and Standards for a Multipurpose Cadastre (NRC, 1983). During this period, the Committee on Integrated Land Data Mapping produced a related report Modernization of the Public Land Survey System (NRC, 1982).

Importantly, these NRC reports have brought attention to a factor missing in many past attempts at implementing and automated information system. This missing factor has been the cadastral or land ownership record (Clapp and Niemann, 1980). The need to define, spatially and legally, our rights in property has resulted in the surveying profession as we know it today in North America. Forward-looking surveyors and their international counterparts, have been instrumental in formulating the concept of a multipurpose cadastre.

In contrast, most geographers and planners involved in geographic information systems have overlooked or seen no value in cadastral information.

> "The many persons whose job it is to regulate land apparently don't know or care about this most basic political and economic fact of the resource they guard." (Popper, 1978, p. 5)

The concept of a multipurpose cadastre offers a spatially based integration of property rights with the uses, values and distribution of natural and cultural resources. The introduction of this concept and its associated terminology has resulted in some confusion as to which term best describes a system which explicitly integrates ownership with other land-based information. Some argue (NRC, 1983; Marble, 1984) that a multipurpose cadastre is a subset of a land information system which is a subset of a geographic information system. Others argue that it is not quite that simple (Hamilton and Williams, 1984). Since most terminology is dependent on professional training and occupational outlook, the debate over terminology cannot be resolved without interdisciplinary negotiation.

For the purposes of this paper, we define a multipurpose cadastre to be interchangeable with multipurpose land information system. "Multipurpose" requires use and access to a mix of routinely maintained records which explicitly includes the cadastral or ownership records as well as some other, independently and spatially defined environmental records.

In order to create a public debate on the conclusions of the National Research Council panels, we offer some comments targetted on a few specific topics. Our intention is not to defeat the overall objectives, which we share, but to explore some technical alternatives which may be more attuned to institutional concerns. Our specific concerns cover three topics: incrementalism, the nature of the basic unit, and compilation procedures. In each section we will explore some dilemmas posed by the proposed "procedures and standards".

MERGING INSTITUTIONAL AND TECHNICAL REASONING

AUTO-CARTO symposia have concentrated almost exclusively on technology without considering institutional concerns. A few authors in related literature have emphasized the negative effects of human institutions on the new technology (Cook, 1969; Moyer, 1977; McLaughlin, 1975; Larsen and others, 1978). Others, particularly at the Ottawa symposium, have suggested that the wrong technologies may be being developed (Bie, 1983; Wellar, 1983). While recognizing that institutions can and do act as barriers to modernization, new technologies can be developed so that the institutional issues reenforce the technical ones.

INCREMENTALISM

Any information system development falls somewhere on a continuum of incrementalism. At one extreme, new procedures are brought in gradually through the effects of routine record-keeping. In the maintenance of land records, it is common to see innovations, such a a parcel index to deeds, established on a "day-forward" basis. A similar incremental approach applies to cartography, where scales of topographic maps shifted from 1:63360 to 1:62500 then to 1:24000, without immediately throwing out the old series. An incremental approach is often the cheapest to implement because it does not require reworking old information. Institutionally, it also produces least disruption. Extreme incrementalism has the problem that it may take a long time (if ever) for the system to be completely modernized.

At the other extreme, modernization can be performed by a wholesale replacement. We term this approach a "parachutted system" because a wholly functional system appears out of the blue to supplant the existing one. While parachutted systems may make sense on technical criteria, and even on economic grounds, wholesale replacement can create institutional friction. Often the reasons advanced for developing a system separately are that skills in the existing agencies are not sufficient (Hanigan, 1979). The experience of other large digital data base projects points towards the opposite conclusion (for example, Huxold and others, 1982). Even in a retrospective of the METROCOM project, Hanigan suggests in a section on "lessons learned" that "data collection, analysis and preparation tasks .. might better be done by the client whose data are being processed" (Hanigan, 1983, p. 147).

The NRC panel does not fit easily on the incrementalism continuum. When it comes to funding, the group is quite pragmatic and expects a twenty year process of implementation. Their fiscal incrementalism corresponds with a hesitance to require digital mapping. The "procedures and standards" talk of the promise of automated systems, but seem to leave substantial room for manual procedures as well. On certain other topics, the NRC panel rejects the incremental approach. This rejection is based on technical reasons explored below.

Computerization

The adoption of computer technology in too many cases has resembled a parachutted model. A whole new technology is acquired without preparing the staff and the rest of the institution. Many parachutted systems fail; for example many of the state natural resource inventory systems are now moribund (Mead, 1981). Such events are probably inevitable in the early years of a technology, but they should not continue.

Computerization is not automatically disruptive. If the initiative arises from existing agency staff who develop skills naturally and gradually, implementation can be positive for all concerned. One example of this process is the City of Milwaukee which rejected a centralized service bureau approach in favor of a model based on upgrading existing agencies (Huxold and others, 1982).

Computers may have been exotic and threatening in the past, but there seems to be much less resistance to them now. Our experience in dealing with local government officials is that we are on the verge of explosive growth in the adoption of automation in land records functions. Even the person making property maps in a county of 16,000 population is considering acquiring a computer drafting system. Rapid adoption of computer technology, if it is unmanaged, could result in each agency going its own way. The promise of a true multipurpose system could be lost.

Geodetic Reference

Adopting the adage for the Public Land Survey System, the NRC panel seems to expect survey and monumentation before anything else. There is little mention of continual improvements in geodetic control. In fact, the report explicitly cautions against underinvesting in the geodetic control network (NRC, 1983, p. 22). Considering the rapid introduction of satellite positioning (Bossler and Hanson, 1984), the panel's conclusions on new technology seem conservative.

We believe that the panel's approach has technical and institutional drawbacks. On the technical side, computer-based maps can be incrementally tied to control in ways that traditional graphic products cannot be. Survey control has logically preceded the rest of mapping efforts due to the nature of manual mapping technology. Even if a massive survey is done first, continual improvement in geodetic information is inevitable. Eventually, any system must be readjusted to fit new observations. On the institutional side, building a geodetic framework could create a dilemma in the competition for funds. The geodetic framework might have long-term benefits, but it might not be able to compete with more immediate needs. One way to diminish the conflict is to begin the implementation of the whole information system, expecting to upgrade the geometry as new control is added. Proponents of accurate positional information should not misinterpret an incremental approach. Descriptions of data quality (Chrisman, 1983) and tests for accuracy (Vonderohe and Chrisman, 1985) should be used to prevent uninformed use. There is a dilemma between quickly satisfying less stringent needs and the possibility that such a process may actually slow down more accurate surveys.

Cadastral Overlay

The report seems ambiguous on the issue of incremental development of the cadastral maps. In one section it recognizes the possibility of an incremental approach (NRC, 1983, p. 57). However, the report also makes the strong statement: "it is particularly important to resist the temptation to use only paper records of mapped locations as a basis for the development of a land-data system in order to save initial costs." (NRC, 1983, p. 22) Data quality is an important concern, which should not be minimized. Still, there may be alternative paths to achieve high quality. For example, in the West German Land of Hesse, existing parcel maps are being digitized for reasons of economy and speed (Eichhorn, 1984, p. 5). Institutionally, the existing paper records have their defenders in the bureaucratic structure. It may be more effective to have these groups participate in the modernization rather than having them fight the process.

NATURE OF BASIC UNIT

The multipurpose cadastre concept, as represented in the 1980 NRC report, uses the land ownership parcel as the basic building block (see Figure 1).

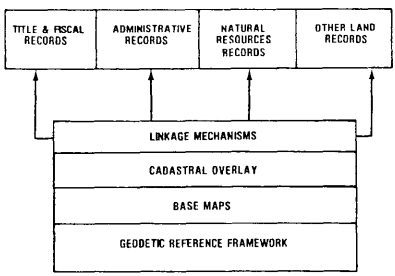
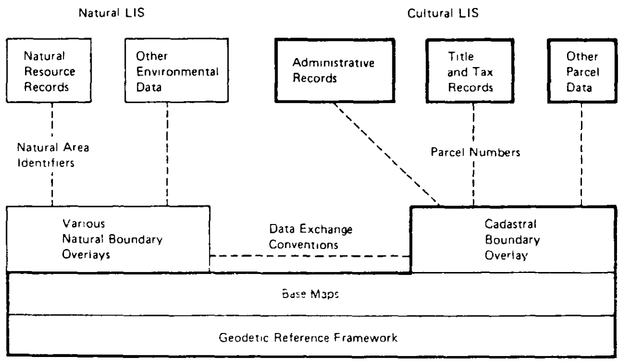


Figure 1: Components of a multipurpose cadastre (1980)

In the 1983 report, the diagram changed to recognize that some forms of land information are difficult to attach to parcels (see Figure 2). The 1983 report still contains the same basic ingredients: geodetic reference, base maps, cadastral overlays and registers of attributes associated with parcel identifiers. The report tries to explain the differences by assigning all non-parcel information to other components of a more broadly defined land information system, not the multipurpose cadastre.



Components of a multipurpose cadastre (in heavy outline) as the foundation for Land-Information Systems (LIS's)

Figure 2: Components of a multipurpose cadastre (1983)

The definition of a cadastral parcel as "a continuous area within which unique, homogeneous interests are recognized" (NRC, 1983, p. 14) runs into institutional trouble in defining those interests. In our experience of building cadastral information for the Dane County Land Records Project (Chrisman and others, 1984), the assessor, the surveyor and the zoning administrator defined parcels somewhat differently. This situation of autonomous behavior, with each actor behaving rationally within a limited horizon, is a part of the land records problem (Portner and Niemann, 1983). The NRC seems to favor the immediate imposition of a unified system. It may be more reasonable to have the divergent approaches merge over time, with the information system as a positive catalyst.

Beyond these institutional difficulties, parcels are hard to define because property rights are affected by a patchwork of environmental concerns with a spatial expression. In Wisconsin, for example, counties perform zoning including floodplains, protect farmland through protective zoning, and will produce soil erosion control plans; the state regulates water pollution, shoreland use, and wetland preservation. This array of public interests in private lands complicates the cadastral concept. Similarly, Eichhorn (1984, p. 9) finds "the parcel as the smallest reference unit loses importance" in rural areas. Environmental information is absolutely crucial to describe the actual interests in the land.

Given that no particular object is indivisible, it may seem to make technical sense to create the currently undivided units and manage them. This approach characterizes the thinking in the early development of topological information systems (Chrisman, 1975) and in the Integrated Terrain Unit phase (Robinove, 1979; Dangermond, 1979). However, managing the overlaid polygons creates difficulties for recording data quality and for maintenance (Chrisman, 1983). A new alternative is needed.

Placing the cadastral parcel as the central focus of an information system also projects the wrong kind of institutional arrangement. A multipurpose system should accept different views of what exists. These different views may be fundamental to keeping each group contributing to the overall system.

Instead of a parcel-based system, a system can be based on handling the features identified by each contributing agency. Each agency is then responsible for their data. Responsibility has to be carefully examined to remove duplication and to ensure cooperation. Such a system could be termed "layer-based". It would have no single permanent basic unit, merely the amalgamation of the units distinguished by the current participants. Individual layers would be integrated as needed (see Figure 3). Of course, this approach depends on reliable integration through geodetic control, but so does any multipurpose mapping system.

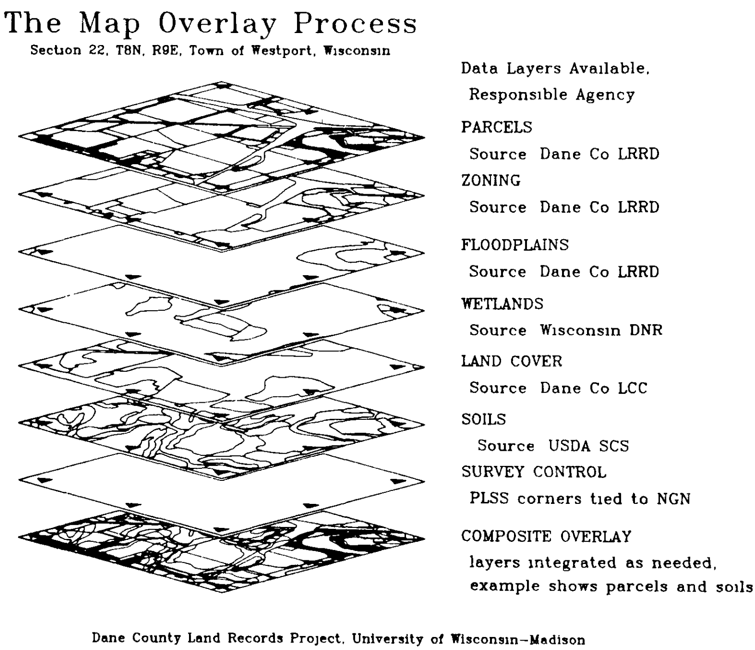


Figure 3: The process of integration through overlay

Another crucial requirement is reliable, robust software for polygon overlay. While this may have been unavailable in the past, recent software systems have conquered this limitation (Dougenik, 1980; Dangermond, 1983). The lesson here is that technical problems, such as integrating layers, can be solved. Systems should not be designed for our imperfect technology, but should reflect the inherent structure of the problem.

Organizationally, a layer-based system is more modular than the scheme proposed on the parcel base. There would be less need for centralization and reorganization. In the long-term a layer-based system would rely on "horizontal" cooperation rather than "vertical" authority.

COMPILATION PROCEDURES

The final issue in this discussion concerns the role of base maps. The NRC report strongly advocates the creation of detailed planimetric base maps as a necessary preliminary to cadastral mapping. The reasoning seems to be mixed.

> "Good planning and engineering practice dictate the preparation of large-scale maps as a basis for sound community development and redevelopment." (NRC, 1983, p. 37)

This important multiple purpose intention may not be applicable in the extensive rural areas with limited engineering needs. In other passages in the report, the cadastral map is seen as an "overlay" related to the geodetic control through the base map. While this approach may have been necessary with previous mapping technology, we believe that this approach misses some of the power of modern digital systems. It also may create institutional conflict.

No mapping professional is opposed to accurate large-scale maps. Greater detail and higher accuracy are assumed to be useful eventually. However, it is easy to place one's own biases into decisions about the features required on a base map. The features on a traditional base map are often selective, not an exhaustive inventory useful in multipurpose analytical situations. In a truly multipurpose system, the needs for base information will vary enormously. An assessor needs an inventory of buildings and thus wants to see through the suburban forest canopy. A wetland expert needs infrared images of a different time of year. Agricultural programs require coverage during the crop cycle. All these needs for "base information" are valid, but they conflict. From reading the NRC report, a rural county in the US might be scared off. We agree that accurate engineering maps form a possible layer in a multipurpose system. However, we do not think that it is required as a "base" to compile the cadastral maps.

Kjerne and Dueker (1984) contrast the methods of constructing a cadastre directly from legal descriptions and surveys with the planimetric base map approach. Although they support the base map approach, the registered survey approach is the common basis for the property systems in some of the countries with functional cadastres (for example, South Africa, and Australia). Kjerne and Dueker (1984) place our research project in an ill-defined category as "implicit base map", but we disagree. Every layer in a multipurpose system must be referenced to the geodetic control network through its coordinate system. No layers are more central than others, although some may be compiled with indirect reference to the geodetic measurements. In a fully operational multipurpose system (which we suspect exists nowhere yet), features in one layer intended to be identical to features in another can be enforced through software, not simply by relying on compilation steps.

In any event, there are substantial legal problems with compilation of property boundaries from physical features. Although fences and other visible features can be used as evidence for boundaries, they are not automatically correct. Other information, only found in deeds and surveys, along with monuments take precedence.

Our conclusion is that the components of a multipurpose cadastre should be revised. The geodetically defined coordinate system plays a central role, serving as the basis for integration of diverse layers through polygon overlay (the ill-defined "data exchange conventions" in the NRC report, see Figure 2). Layers will be compiled by different approaches, such as direct photogrammetry based on geodetic control, or compilation on existing map products.

One important method has particular application to the Public Land Survey portion of the United States. The treatment of PLSS section corners is a major technical issue, because the NRC "procedures and standards" insist on legal remonumentation and accurate survey as the basis of the whole process. We believe that they underestimate the power of digital technology to transform coordinates and warp data to fit new control. In one passage, the report talks about wasting all of the investment on inaccurate information (NRC, 1983, p. 22). With traditional mapping, this may be true, because distortions would not be removed. In a digital environment, however, it is possible to remove systematic errors at a later time, once they are detected. Although it runs counter to the "procedures and standards", the Panel on Integrated Land Data Mapping (NRC, 1982) suggested a focus on the PLSS corners, beginning with digitizing information from the 1:24000 quadrangles. While this may seem unacceptably crude for urban engineering projects, it may prove sufficient to ensure that resource information and other data for rural areas are at least put into a spatially referenced framework leading towards a multipurpose system. In our experience with tying existing soils maps to a geodetic framework, we found the PLSS corners to be more useful than the other "well-defined" features normally shown on a base map. This result is specific to a particular landscape, but it indicates a role for the PLSS corners in a future digital multipurpose system.

SUMMARY

A multipurpose cadastre will be achieved more smoothly and operate more effectively if the technical and institutional components are in tune. We suggest that data sources must be seen as incremental. Computerization, by contrast, should be expected to be rapid. A true multipurpose system will have no simple basic unit; it must be based on separate layers maintained be cooperating agencies. The layers must rely on the coordinate system, not a base map, for integration.

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