Geographic Information Systems as a Decision Making Tool

I. Introduction

Many of the decisions made by lawyers, judges, planners, and government agencies concern land and its use. Examples include rezonings, environmental permits, land development, tax appraisals, and voter precinct boundaries. These decisions require a choice between alternatives, and "[i]nformation is the essential ingredient of choice . . . ."[1]

Information can be considered a commodity, "for it takes resources to produce and it can usually be bought and sold."[2] However, information is a commodity with some peculiar properties. Information can be transfered and yet remain with the transferor.[3] The benefits of information can be realized more than once (*i.e.* each time it is used).[4] Information is non-consumable, in that it remains after it is used.[5] Therefore, if information is of a type needed by many users, the information can be gathered and disseminated at a low cost per user if the costs are shared.

The concept of gathering land information for use by many is by no means new. One example of the acquisition of land-based information can be found in the *Instructions to the Surveyor General of Oregon.*[6] Land surveyors who were to survey the vast wilderness of the Oregon Territory were required to locate, note, and describe the land's surface, soil, timber, bottom lands, springs, lakes, ponds, rivers, mills, mines, roads, and natural curiosities of the land.[7]

Fortunately, we are no longer constrained by the crude instruments and techniques of our nineteenth-century counterparts. Technological advancements have aided in the acquisition, storage, retrieval, and display of land-based information. Maps can be made from aerial photographs; positions on the surface of the earth can be determined from satellite observations; and computers can be used to capture and process data. Therefore, the technology exists to gather, store, and retrieve vast amounts of information.

Today, land-based information is often placed in what is termed a Geographic Information System (GIS—the abbreviation is used as both a singular and plural).

> 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

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1. E. Mackaay, Economics of Information and Law 107 (1982).
2. *Id.* at 113.
3. P. Dale & J. McLaughlin, Land Information Management 170 (1988).
4. *Id.* at 170.
5. *Id.* at 170.
6. Instructions to the Surveyor General of Oregon; Being a Manual for Field Operations (1851) *reprinted in* C. White, A History of the Rectangular Survey System 433 (1983).
7. *Id.* at 444.

of geographically referenced information that may be relevant for research, management decisions, or administrative processes.[8]

This Note will discuss the components of a modern GIS and what can be accomplished with modern computer-based systems. The Note will also consider possible applications of GIS to legal disputes. Costs, benefits, and the caveats of use and misuse will also be considered. This Note will not, however, discuss computer hardware requirements or procedures for implementation of a GIS.

II. Overview of Modern GIS

The four major parts of a GIS are: (1) the hardware (computer, monitor, plotter, disk drives); (2) the software; (3) the database; and (4) the personnel to operate the system. The types of data stored in modern GIS databases and examples of the types of data analyses which can be performed by the GIS are described in this section.

A. *The Database*

The database of a GIS consists of two major parts: graphical (map/spatial) information and tabular information. The former contains data about the location of features, and the latter contains non-spatial information associated with the features. For example, the database may contain graphical line symbols that represent high tension powerlines. Each section of the powerline line symbol could have tabular information associated with it, describing the voltage, amperage, and date of construction. The two components are linked, such that one may be accessed by addressing a portion of the other.

Graphical information is arranged in layers, called levels or overlays. Data levels are merely files in the database segregated by the type of information. One level includes all streets, roads, highways, and airports. Another level contains buildings and structures. A third level may contain streams, lakes, ponds, and artificial bodies of water. Other levels may contain contours, floodplains, wetlands, soil types, utility lines, vegetation cover, and land use.[9]

The information stored in these overlays is gathered with respect to a geodetic reference framework, such as a state plane coordinate grid.[10] The state plane coordinate grids are mathematical surfaces as depicted below in Figure 1.

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8. National Research Council, Procedures and Standards for a Multipurpose Cadastre 14 (1983).

9. *Id.* at 37.

10. *Id.* at 41; *see generally*, R. Cook, *Land Law Reform: A Modern Computerized System of Land Records*, 38 U. Cin. L. Rev. 385, 401 (1969).

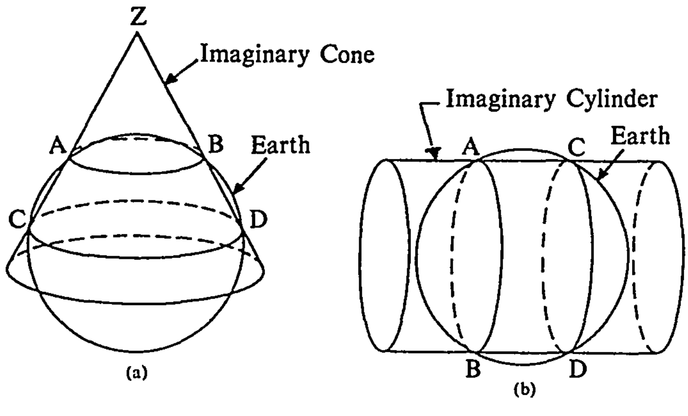

Figure 1 [11]

The positions of features on the earth's surface can be projected onto the surface using mathematical formulas. The end result of this mathematical projection is a pair of numbers called coordinates. The coordinates describe the specific place on the earth's surface where the feature is located. Coordinates are nothing more than distances north and east of the point of origin on the state plane coordinate grid system.

Since the location of each feature on the earth's surface is known, the spatial relation of one feature to another can be determined. This concept is known as registration. Figure 2 illustrates correspondance of layers in a database.

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11. *Reprinted from*: R. Brinker & P. Wolf, Elementary Surveying 350 (6th ed. 1977). The National Geodetic Survey develops either a transverse Mercator or a Lambert conformal conic projection system for each state. These state plane projection systems are usually adopted by each state legislature. *See, e.g.*, Ohio Rev. Code Ann. §§ 157.01-157.03, 157.05-157.06 (Baldwin 1987); and Ariz. Rev. Stat. Ann. §§ 33-121 to 33-138 (1990).

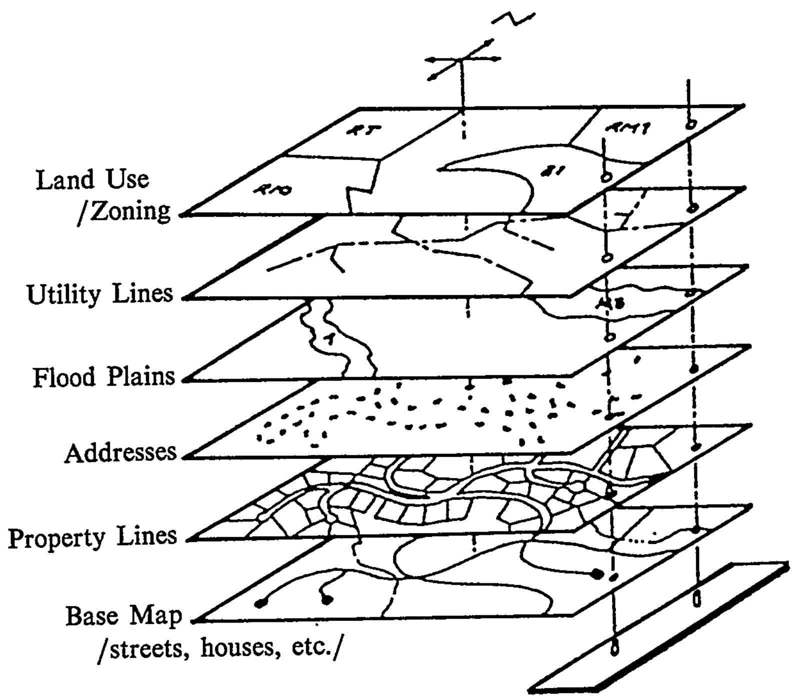

Figure 2[12]

The second half of the database consists of tabular information. Tabular information associated with a parcel may include the name of the parcel owner, a parcel identifier, appraised value, mailing address, land classification, and land use. The tabular data is linked to the graphical data, and vice versa, as shown in Figure 3.

12. *Reprinted from*: NATIONAL RESEARCH COUNCIL, PROCEDURES AND STANDARDS FOR A MULTIPURPOSE CADASTRE 42 (1983).

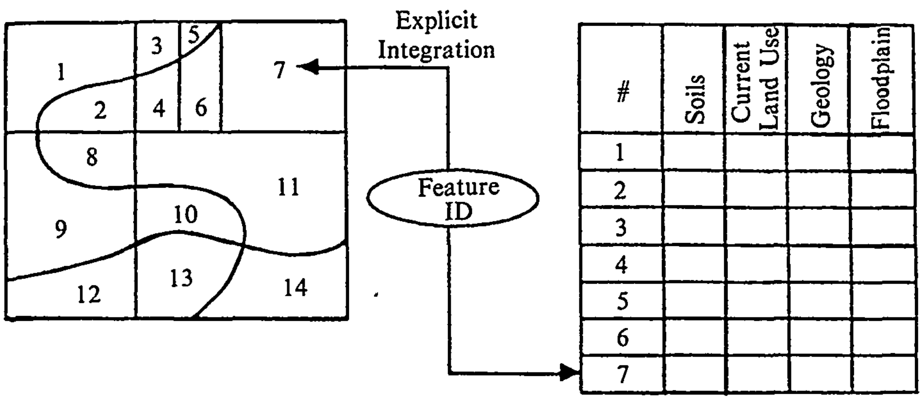

Figure 3[13]

Using both the graphical and tabular information together yields greater flexibility and versatility than using them separately. For example, spatial information lends itself quite readily to graphical/map representation where a description in words would be cumbersome. On the other hand, a map symbol meaning "historical monument" could not convey the historical information the monument memorializes. A GIS database allows both types of information to be stored and used simultaneously.

B. *Present GIS Usage*

Geographical Information Systems are currently being studied, developed, and used at the federal, state, and local levels. GIS are also being used in private industry. These GIS are in different stages of development and contain information of varying accuracies.

At the federal level, at least twenty-one federal agencies use land information.[14] However, a national GIS does not exist at this time. A study has been

13. *Reprinted from*: ENVIRONMENTAL RESEARCH SYSTEMS, INC., ARC/INFO SOFTWARE DESCRIPTION 4 (May 1989).

14. U.S DEPARTMENT OF THE INTERIOR, A STUDY OF LAND INFORMATION 29 (1990). These agencies include: Bureau of Land Management, U.S. Geological Survey, National Park Service, Fish and Wildlife Service, Bureau of Reclamation, Bureau of Indian Affairs, Minerals Management Service, Bureau of Mines, Office of Surface Mining, National Oceanic Service, Bureau of Census, National Institute of Standards and Technology, U.S. Forest Service, National Agricultural Statistics Service, Agricultural Research Service, Agricultural Stabilization & Conservation Service, Foreign Agricultural Service, World Agricultural Outlook Board, and the Animal, Plant & Health Inspection Service.

made, pursuant to the Federal Land Exchange Facilitation Act of 1988,[15] to determine the feasibility of setting up a GIS at the national level.

States maintain several different policies with regard to land information.[16] Some states continue to work with land records and information systems independently (no coordination between agencies and other government entities)[17] while some states have interagency committees to study, recommend, and set policy for land-based information.[18] Some other states have developed a single office with the responsibility over land information activities.[19]

Most of the GIS activity is carried on at the local (city and county) level.[20] While some local governments continue to maintain conventional land data records, other government agencies, such as the County Auditor of Franklin County, Ohio, have made a commitment to a county-wide GIS.[21]

Whether carried on at a local or state level, the present and future uses of GIS are varied. GIS can be used for urban and regional planning[22] and rezoning.[23] Enviromental uses of GIS include modeling nonpoint source pollution[24] and monitoring oil spills.[25] GIS will also be used for emergency preparedness and hazards mapping, including both man made and geologic hazards.[26] Another use of GIS includes redistricting of voter precinct boundaries.[27] This list of GIS uses is by no means exhaustive and does not include the potential myriad of uses by private citizens.

III. Information Costs and the Advantages of GIS

A. *Information Costs*

The world is a place where resources are limited in relation to human wants.[28] As such, economics is the science of rational choice.[29] Choice is a selection among available alternatives, often made in the face of substantial uncertainty. Geographic information systems are designed and implemented with the

15. Federal Land Exchange Facilitation Act of 1988, Pub. L. No. 100-409, § 8, 102 Stat. 1086 (1988) (codified at 43 U.S.C. § 751 (1988)).

16. U.S. Department of the Interior, A Study of Land Information 29 (1990).

17. *Id.* at 31.

18. *Id.*

19. *Id.*

20. *Id.* at 33.

21. *Id.*

22. Ehlers & Hagerty, Interfacing *Remote Sensing and GIS Technologies for Urban and Regional Planning*, 1Annual Conference of The URBAN and Regional INFO. Sys. A. 85 (URISA Vol. I 1989).

23. Burns, *Geographic Rezoning* 4Annual Conference of The URBAN and Regional INFO. Sys. A. 1 (URISA Vol. IV 1985).

24. Pickett, Thum & Nieman, *Using GIS Technology to Integrate Nonpoint Source Pollution Modeling and Land Use Development Planning*, 1Annual Conference of The URBAN and Regional INFO. Sys. A. 373 (URISA Vol. I. 1989).

25. Enviromental Systems Research Institute, *Prince William Sound, State and Federal Agencies in Alaska Apply ARC/INFO to Oil Spill Disaster*, 11 ARC News 1 (Summer 1989).

26. Johnson & Patel, *Emergency Preparedness and Hazards Mapping Using GIS*, 1Annual Conference of The URBAN and Regional INFO. Sys. A. 337 (URISA Vol. 1 1989).

27. *See* ARC News *supra* note 25, at 32.

28. R. Posner, Economic Analysis of Law 3 (3d ed. 1986).

29. *Id.*

faith that more information will have a positive effect on the decision making process, with the end result of better decisions.[30]

Some economic theories assume that perfect information is available, although this is not always true in the real world. Information is a commodity which costs money and resources to produce. The decision maker has a choice among alternatives. He can act without information and assume the risk in his decision. The decision maker could also spend the money and resources to obtain information to reduce the risk of his decision. However, there will be a point at which the cost of information begins to exceed the benefit in the reduction of risk. Therefore, decision making does not entail a search for the best information, but the "best information worth searching for."[31]

The driving force behind GIS and information science in general is to provide more information at less cost. This concept has some significant impact in the decisionmaking process. If information can be provided at a reduced cost, more information can be obtained to reduce the risk of decisions.[32] Also, decision makers will search more for information.[33] Therefore, if information that is necessary for decision making can be provided at a reduced cost, better decisions and reduced risk should result.[34]

B. Ad Hoc *Versus* A Priori *Information*

An important concept to understand when considering the benefits of a GIS is the difference between ad hoc and a priori data gathering.[35] Ad hoc data gathering is the traditional method of gathering data at the time a dispute arises. A priori data gathering occurs before a dispute arises in anticipation of the event.[36]

In an a priori system such as GIS, data exists in a central location. The information is gathered in anticipation of the need by many, and the costs of gathering the information can be shared among the many end-users.[37] The conventional ad hoc system requires information to be gathered at every conflict, causing inefficiency, excess cost, and redundant information gathering.

The inefficiency of an ad hoc system comes from many sources. For example, an ad hoc system carries redundant costs of finding the data and verifying that the data is correct. Each project may require separate trips to the assessor, county engineer, county recorder, water department, or soil conservation service to gather separate pieces of information such as plats, maps, deeds, and reports.

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30. Epstein, *Development of Spatial Information Systems in Public Agencies*, 13 COMPUT., ENVIRON. AND URBAN SYSTEMS 141, 143 (1989).

31. *Id.* at 144.

32. E. MACKAAY, ECONOMICS OF INFORMATION AND LAW 258 n.10, (1982).

33. *Id.*

34. Epstein, *supra* note 30, at 143-144. However, Professor Epstein warns that the information used to make decisions must be of sufficient accuracy before its use is appropriate. Also, geographical information must be used in conjunction with other factors such as social values, law and economics.

35. *Id.* at 147.

36. *Id.*

37. Determining the method for sharing data is one of the most difficult issues in GIS. *See infra* text accompanying notes 79-83.

Gathering these pieces of information for the decisionmaking process can be time consuming and costly. Not only are the maps in different places, but it is often difficult to find them, or even to determine whether they exist. While an a priori system also has "seek and verify" costs, these costs are only incurred once. An ad hoc system must seek and verify costs every time information is obtained.

Assembling the information for the decision making process can be very time consuming and difficult with an ad hoc system. Conventional maps are often drawn on different scales, so that they cannot be directly compared. Also, conventional paper map products often do not contain common points of reference that would allow maps concerning a specific place on the earth's surface to be compared.

A GIS, formed from a priori digital information, can also be of more value than paper-based information. Maps and other types of information are created and are current at a given date. As circumstances change and maps become outdated, their information value decreases. For example, a zoning map is out of date as soon as one or more of the parcels are rezoned.

Unlike digital databases, it is impractical to update conventional maps on a regular basis. Updating paper maps requires redrafting of the original and printing of a new map. Due to the great expense, conventional maps are not often updated.

GIS allow greater ease in updating, since the information is easily accessed by the computer. GIS graphical products therefore provide more recent information than conventional maps. Some experts suggest that GIS databases be updated on a weekly basis.[38] It would be impossible to update paper maps frequently, and as a result, GIS databases often are of greater value than paper maps, which may be months or even years old.

C. *Advantages of a Digital Database*

The flexible nature of a GIS allows users to accomplish tasks very efficiently. A GIS can accomplish these tasks because all of the necessary data is in one place and is in a digital format for easy computer access.

For example, the computer can be queried to produce a list of all parcels with an appraised value greater than $100,000 which lie within 3000 feet of Blackacre. The computer would then search the database and list all such parcels. The computer could draw a map of all vacant parcels of land within 3000 feet of Blackacre or a composite map showing specific features from any or all of the layers of data in the database.

The GIS is also used to execute calculations, such as elevations at specific points on the earth's surface, distances between points, areas, ground slopes, and the nature of the terrain by means of block diagrams.

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38. NATIONAL RESEARCH COUNCIL, PROCEDURES AND STANDARDS FOR A MULTIPURPOSE CADASTRE 56 (1983). Some types of data require updating more often than others. For example, parcel ownership records may require updating weekly, while government boundary lines may only change on rare occasions.

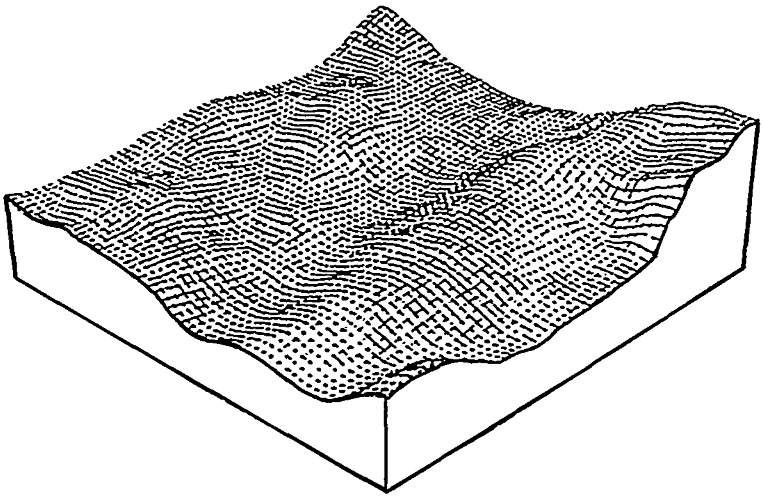

Figure 4[39]

Block diagram of DEM computed from a 60 x 60 point altitude matrix of a 3750 x 3750m area of the Kisii District, SW Kenya.

IV. An Example Application

GIS could be very useful in land use planning and zoning. For example, consider the requirements for a rezoning or other small-scale amendment to a zoning ordinance. *Fasano v. Board of County Comm'rs of Washington County* contains an outline of the general requirements for rezoning in Oregon.[40]

For a small-scale change to be valid, the change must conform to the city's comprehensive plan.[41] The *Fasano* court stated that, at a minimum, the applicant must show that "(1) there is a public need for the change of the kind in question, and (2) that need will be best served by changing the classification of the particular piece of property in question as compared with other available property"[42] in order to conform to the comprehensive plan.

The *Fasano* court also stated that a change in the zoning ordinance might be proper, even in the absence of a mistake in the original plan or ordinance or in the event of a severe change in circumstance.[43] However, the court noted that

39. *Reprinted from*: P. Bourrough, Principles of Geographical Information Systems for Land Resources Assessment 46 (1986). Geographic Information Systems do not automatically give the ability to do all types of calculations and data manipulations. Questions involving data structure, software, and data accuracy are critical. *See generally*, P. Dale & J. McLaughlin, Land Information Management, ch. 7 (1988).

40. 264 Or. 574, 507 P.2d 23 (1973), *rev'd in part* Neuberger v. City of Portland, 288 Or. 155, 603 P.2d 771 (1980).

41. *Id.* at 583, 507 P.2d at 28.

42. *Id.* at 584, 507 P.2d at 28. *But see*, 288 Or. 155, 603 P.2d 771 (1980). The court decided that this is no longer required but still quite relevant.

43. The court also set forth four other guidelines which bear upon the small-scale change process. These are (1) parties to a zone change are entitled to a hearing; (2) parties should be able to present and rebut evidence; (3)

such mistakes in the original plan or changes in circumstances could be relevant to the decision of whether rezoning is proper.

Consider a case in which a client wishes to change the zoning of his parcel from commercial to multi-family residential. The first step would be to identify the reasons for rezoning that particular parcel. A query to the GIS computer could produce a map showing the client's parcel and highlighting the various types of land uses within 2500 feet of the parcel. The map would show all of the apartment complexes within the neighborhood in relation to the location of businesses and industries where the people work.[44] This map, coupled with a low vacancy rate in existing apartments, would indicate a need for a change in zoning.

In addition, the client would typically need to show that rezoning his parcel, as opposed to nearby parcels, would best serve the public's needs. Other parcels can be divided into two categories: those potentially available and those immediately available.[45] Immediately available parcels are those which are vacant and already zoned for the intended purpose; potentially available parcels are those which are vacant, but will also require a zoning change. In addition, the computer can plot only those parcels that lie on arterial or collector streets,[46] because the Oregon court has recognized that higher-density residential areas should be located in areas with streets which can handle the traffic flow.[47]

The GIS computer could produce a color-coded map to show all vacant parcels on arterial or collector streets that are: (1) presently zoned for multi-family residences within 2500 feet of the client's parcel or (2) zoned other than multi-family residential within 2500 feet of the client's parcel. This map would show what parcels are available to fulfill the housing need.

The person seeking a rezoning generally must also show that a proposed zoning change will not have an adverse impact on the neighborhood. Therefore, the person seeking the change must prove that the present utilities are sufficient to handle the increased population.[48] The GIS could provide a map showing the locations of all water, sewer, gas, electric, and drainage lines in the vicinity of the parcel and could list the capacity of each utility.

The GIS can also be used to show mistakes in the comprehensive land use plan which may show that the client's parcel should be rezoned. For example, a slope map can be produced in order to show the slope of the ground and the parcel boundary. If the slope is greater than five percent, a change from commercial to residential zoning may be warranted, since slopes of five percent or

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a record of the hearing shall be made, and adequate findings executed; and (4) that there shall be no ex-parte or prehearing communications in order to ensure that the proceedings are impartial. Fasano v. Board of Commissioners of Washington County, 264 Or. 574, 588, 507 P.2d 23, 30 (1973), *rev'd in part* Neuberger v. City of Portland, 288 Or. 155, 603 P.2d 771 (1980).

44. A PLANNER'S GUIDE TO LAND USE LAW 52-53 (S. Meck & E. Netter eds. 1983).

45. *Id.* at 53.

46. *Fasano*, 264 Or. at 587 n.3, 507 P.2d 29, at 29 n.3.

47. *Id.*

48. *Id.*

more are too steep for parking lots or the large trucks that are necessary for commercial business.[49]

Some experts believe that a GIS is not needed for land use planning cases such as the one illustrated above. The argument is that the information required already exists or can be gathered when needed. However, this argument misses the point that the GIS can provide information far more efficiently and effectively than can conventional paper-based recordkeeping systems. Assembling the information used in this example could take countless hours at great expense using conventional methods. A GIS could provide the information in minutes, at a greatly reduced cost.

For example, a map showing the client's parcel with all of the utilities displayed would require collecting maps from the gas company, water company, power company, the local sanitary district office, and the county engineering departments if conventional paper-based records are in use. A composite map would then have to be compiled by hand using these maps, which may be of different scales and dates. If these maps do not contain true reference points, compilation may be extremely difficult, and it may become necessary to set up a field visit to the parcel for the purposes of relocating the utilities and preparing yet another paper map.

Such procedures are unnecessarily time consuming and expensive when done on an ad hoc basis every time a conflict arises. When a GIS is used, all of the relevant information is easily accessible at a single location, and the computer can perform all of the required calculations and can produce a single map containing the compiled information.

V. EVIDENTIARY ASPECTS OF GIS

Maps and other types of graphical information are often used in court. Sometimes, the maps are used as demonstrative evidence which is "subsequently constructed or obtained by the parties to illustrate or demonstrate their factual contentions or to help the jury understand the case"[50] even though such evidence is not directly involved in the litigation. Maps can also be used as real evidence in a trial if they are relevant, *i.e.* if they can make a fact of consequence to the determination more or less probable.[51] Also, maps must be authenticated before they are admissible in evidence. Authentication is a process of verifying that a map or other document is what its proponent purports it to be.[52]

Even though maps may be relevant, they still may not be admissible as evidence. The major reason that maps and other types of graphical information are not admitted as evidence is that they are hearsay.[53] The hearsay rule covers

49. Parking lots should never exceed a grade of 5%. J. DECHIARA & L. KOPPELMAN, TIME-SAVER STANDARDS FOR SITE PLANNING 220 (1984).

50. G. LILLY, AN INTRO. TO THE LAW OF EVIDENCE 511 (2d ed. 1987).

51. FED. R. EVID. 401.

52. FED. R. EVID. 901.

53. Hearsay is defined as a statement, made out of court, and offered for its truth. FED. R. EVID. 801(c).

both oral testimony and writings, such as maps. Therefore, many ad hoc map products would not be admissible due to the hearsay rule.

The exceptions to the hearsay rule that would allow the admission of GIS records are Federal Rule of Evidence 803(6), commonly called the business records exception, and Federal Rule of Evidence 803(8), known as the public records exception.[54] The discussion of the applicability of these rules will be limited to consideration of admissibility of those records kept by government organizations, specifically since most databases will be maintained by the government.

The business records exception to the hearsay rule is a common law rule which has been codified in most jurisdictions. Federal Rule of Evidence 803(6) applies to memoranda, reports, records, or data compilations in any form that are "made at or near the time by, or from information transmitted by, a person with knowledge, if kept in the course of a regularly conducted business activity . . . unless the source of information or the method or circumstance of preparation indicate [a] lack of trustworthiness."[55] Records that fall under the business records rule are admitted in evidence as an exception to the hearsay rule because of their indicia of reliability.[56]

Business records are regarded as reliable, for example, because they usually are made in a timely fashion, eliminating the hearsay problem of fading memory.[57] Similarly, the "reliability of business records is said variously to be supplied by systematic checking, by regularity and continuity which produce habits of precision, [and] by actual experience of business relying upon them."[58] In addition, the informant and the entrant must be under a business duty to report[59] and that the record must be made in the regular course of business.[60] A record prepared for litigating a specific suit will not be admitted because such a record is not kept in the regular course of business activity. However, GIS information is gathered a priori without specific litigation in mind. Therefore, GIS information would fulfill the requirements of the business records exception to the hearsay rule.

Government agencies can be considered "businesses" under the broad language of Rule 803(6).[61] This rule is also the most commonly used rule for admitting computer information. Rule 803(6) may have some limitations with respect to GIS. Information that is already available in the form of conventional paper maps is sometimes entered into the database. Because this information

54. This discussion will be limited to the federal rules of evidence which have been adopted by 31 states.

55. FED. R. EVID. 803(6).

56. FED. R. EVID. 803(6) advisory committee's note.

57. FED. R. EVID. 803(6).

58. FED. R. EVID. 803(6) advisory committee's note.

59. Johnson v. Lutz, 253 N.Y. 124, 170 N.E. 517 (1930); United States v. Baker, 693 F.2d 183 (D.C. Cir. 1982).

60. This means that the record must not be prepared solely for litigation. Palmer v. Hoffman, 318 U.S. 109 (1943).

61. Generally, admissibility of computer eivdence has been treated under Rule 803(6). Lacey, *Scientific Evidence*, 24 JURIMETRICS J. 254, 267 (1984). *See*, United States v. Orozco, 590 F.2d 789, 793 (9th Cir. 1979); United States v. Sanders, 749 F.2d 195 (5th Cir. 1984). G. LILLY, AN INTRODUCTION TO THE LAW OF EVIDENCE 270 (1987).

may sometimes be years old, it will not have been entered in a timely fashion as required by Rule 803(6). Another potential problem is that much of the information may not come from an informant who is under a business duty to report. If the informant does not have a duty to report, the information may be less reliable.

Additionally, a problem common to all types of computer records is that the information comes from a computer. Cases indicate a reluctance by some courts to accept computer-based information because the information may be considered by the court to be unreliable.[62] Therefore, some courts may require information on how the data is transmitted to the computer and on the accuracy of work produced by the computer.

The second avenue for introducing GIS information into evidence is the public records exception. Federal Rule 803(8) applies to

> [r]ecords, reports, statements, or data compilations, in any form, of public offices or agencies, setting forth (A) the activities of the office or agency, or (B) matters observed pursuant to duty imposed by law as to which matters there is a duty to report, . . . unless the sources of information . . . indicate [a] lack of trustworthiness.[63]

The admission of GIS information under Rule 803(8) provides several advantages over the use of 803(6). Under 803(8), the proponent need not show that both the entrant and the informant were under a business duty to report the information. Also, Rule 803(8) is not concerned with the time when the record was made. This exception is justified upon the theory that public officials will perform their duties properly.[64] In addition, this exception to the hearsay rule is necessary because, due to the sheer volume of records encountered by public agencies, public officials would be unlikely to remember details about a given public record if they were called to give testimony.[65]

In addition, the rule still has a provision that permits the court to exclude public records deemed to be untrustworthy. For GIS information to be admissible, it must be regarded by the court as reliable using some criteria such as the five conditions of reliability set out by Lacey.[66]

With respect to the evidence rules of various states, some require that the duty to collect and maintain a public record must be imposed by statute before the record is admissible.[67] However, most courts, including the federal courts, allow evidence to be admitted if the record is kept in the discharge of a public duty.[68]

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62. Lacey, *supra* note 61, at 269-70. Factors given for the judgment of unreliability include: "(a) environmental factors can damage the magnetic workings of even a sturdy computer; (b) factors or errors in hardware are more likely in some systems than in others; (c) errors in programming at all levels are, of course, more frequent as a system becomes more sophisticated . . .; (d) . . . the accuracy of the operator; (e) the input of improper or inaccurate information." *Id.*

63. FED. R. EVID. 803(8). The rule, in other provisions, restricts the use of public records in criminal trials due to confrontation clause considerations.

64. FED. R. EVID. 803(6) advisory committee's note.

65. FED. R. EVID. 803(8) advisory committee's note.

66. *See supra* note 52.

67. Annotation, *Admissibility, Under Public Records Exception to Hearsay Rule, of Record Kept By Public Official Without Express Statutory Direction or Authorization*, 80 A.L.R. 3d 414, 428-29 (1977).

68. *Id.* at 422-23.

Under both 803(6) and 803(8), records of public agencies are self-authenticating if a copy is "certified as correct by the custodian or other person authorized to make the certification, by certificate complying with paragraph (1), (2), or (3) of this rule [902] . . . ."[69] GIS information thus has great potential evidentiary value because of the applicable hearsay rule exceptions and its self-authenticating feature.

VI. Cost Analysis and Caveats of GIS Usage

A. *Cost*

One of the natural questions to ask when discussing GIS usage is whether the use of a GIS will result in a significant cost savings when compared to the use of conventional paper-based information. Unfortunately, a precise cost/benefit analysis can be elusive for several reasons.

First, measurement of the quantity of benefit is often difficult. Benefit can be measured by (1) how many decisions involving land based information will be made; (2) how the decision makers will process the information; and (3) how the change in the form of the information will affect the individual decisions made.[70]

Second, the cost estimate of a GIS cannot be made until a specific system has been selected. The cost of a GIS depends upon the comprehensiveness of the system, its accuracy, and the availability of information for input to the GIS database. These factors must be determined prior to the implementation of a GIS, and only then can the cost be estimated. Most experts agree that the cost of gathering the information and keeping it updated exceeds the cost of the hardware and software.[71]

The cost of gathering data for the data base depends upon what types of information are going into the data base and how much data already exists. One estimate states that costs for a planimetric base map and parcel boundary layers can average $20 to $25 per parcel, assuming useable maps exist.[72] In a county that may have as many as 300,000 parcels, this can be quite a large sum. Each of the other layers of data will result in additional costs. For example, the estimated cost of the soils layer for Dane County, Wisconsin was $34,681.[73] The data for the soils layer was already in existence and of suitable accuracy. If the data had to be gathered from field work, the cost would be

69. FED. R. EVID. 902(4).

70. P. DALE & J. MCLAUGHLIN, LAND INFORMATION MANAGEMENT 175 (1988). The number of decisions involving land information could be estimated to some degree from the number of court cases, rezonings, and other decisions that currently take place. The other two questions posed are very subjective and virtually unanswerable.

71. S. McRea & P. Durgin, *An Introduction to GIS*, POINT OF BEGINNING 12, 18 (Oct.-Nov. 1989).

72. *Id.* at 18.

73. Green & Moyer, *Implementation Costs of a Multipurpose County Land Information System*, 1 ANNUAL CONF. OF THE URB AND REGIONAL INFO. SYS. A. 149 (1985).

considerably greater. Similar costs may be incurred for the zoning, land use, and floodplain layers.[74]

Some agencies try to reduce cost by entering existing information into the database. This practice can be a mistake if the accuracy of the existing information is insufficient for proposed use of the database.[75] The computer thus becomes a filing cabinet for inaccurate data that will not be enhanced by the use of the computer. While the speed and efficiency of a computer are attractive, data and information are subject to the "garbage in, garbage out" GIGO principle meaning that a computer cannot enhance erroneous inaccurate data.[76]

Fortunately, the costs of hardware and software have been decreasing in recent years. Estimates for a GIS work-station type hardware and software system range from $30,000 to $50,000.[77] While such a system might be appropriate for county government, larger systems suitable for state and federal government would cost considerably more.

Another cost associated with GIS is for personnel. For the most part, a GIS must be staffed with people having technical backgrounds such as cartography, geography, engineering, and computer science. These people must be trained on the system which typically requires ten to fifteen days at $250 to $500 per day.[78] The salaries of these people will also remain a recurring cost each year.

The great cost can be a primary concern when developing a GIS. One method of financing a GIS is through the government budget which may not be very promising expecially in harsh economic times.[79] Another alternative would be to finance a GIS by charging user fees for the final products. Under this approach, the user would pay for the costs of reproduction of the map products and a fee to pay for the implementation, development, and maintenance costs. This alternative may not be promising either since the various state and federal Freedom of Information Acts only allow charges for reproduction. Therefore, the costs of gathering information and maintaining the system may not be recoverable.

The inability to recapture costs is part of another problem, that of providing public access. Some administrators of GIS databases are frustrated when resources needed to maintain and update the databases are used to pay for responses to public requests for information.[80] Similarly, adminstrators also worry about liability, confidentiality of information, and resale of information by private organizations. This frustration does not stem from an opposition to the

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74. The cost of a GIS can invoke a lot of criticism. For example, the GIS at the Franklin County, Ohio Auditor's Office is estimated to cost $17.3 million. Critics complain that the cost is too high, the cost may never be recovered, and the money for funding the project came from the wrong place. Riskind, *County Counting on Computer's Maps*, The Columbus Dispatch, Oct. 14, 1990, at H1, col.1.

75. Epstein, *supra* note 30, at 148-51.

76. Lacey, *supra* note 61, at 270.

77. S. McRae & P. Durgin, *supra* note 71, at 18.

78. *Id.*

79. For example, the Governor of Florida vetoed a $455,000 appropriation for a study concerning the implementation of a state wide GIS. Florida House of Representatives v. Martinez, 555 So. 2d 839, 842 (Fla. 1990).

80. Roitman, *Towards a Practical Policy on Public Access to Automated Mapping Data Bases*, 4 ANNUAL CONF OF THE URB AND REGIONAL INFO. SYS. A. 187-88 (1986).

public's right to be informed. On the contrary, providing information to the public helps justify the need and importance of GIS databases.[81]

Roitman argues that much of the public access problem stems from the various state and federal Freedom of Information Acts which were simply not designed to handle the vast range of computerized information currently available.[82] Roitman maintains that a practical policy is feasible, perhaps by leasing agency databases, selling databases to private companies, or creating non-profit corporations.[83] The company could then sell the information without constraint or limitation.

B. *Liability*

Another troublesome point is the potential liability for providing information. The possibility of an error in information exists regardless of whether the information is in digital form or in the form of conventional paper maps. The data in a specific database may be excellent by all standards. However, the sheer magnitude of information that can be produced by a GIS and the potential for heavy use of the database may result in errors. An error in information provided to an end-user could provide a cause of action for negligence. One commentator has raised the question of whether charging fees for information may eradicate the defense of sovereign immunity.[84] Therefore, providing information may lead to unwanted exposure to liability if an error in the database should occur.

Spatial information can also be misused or misinterpreted. Misuse of spatial information is not restricted to GIS, but includes conventional map products as well. A typical misuse situation occurs when information is needed for a decision and an inappropriate map product is used because it is the only information available.

There are several ways to combat map misuse. The end-users of spatial information must have a clear understanding of what a GIS system can and cannot do if GIS map products are to be marketed.[85] Also, GIS systems need information specialists with both technical and nontechnical training to advise the end-user of the appropriateness of the information for specific decision making.[86] Suggestions have also been made to structure the data so computer operations requiring higher accuracy information cannot be performed.[87] In these

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81. *Id.* at 187.

82. *Id.* at 190.

83. *Id.* at 193.

84. Puissegur, *Does Charging for Public Information Eradicate the Defense of Sovereign Immunity*, 4 ANNUAL CONF. OF THE URB AND REGIONAL INFO. SYS. A. 358 (1988).

85. Epstein, *Liability for Information*, 4 ANNUAL CONF. OF THE URB AND REGIONAL INFO. SYS. A. 119 (1987).

86. Epstein, *Legal Conflict over Land Data and Information: A Basis for the Profession of Land Information Specialist*, 4 ANNUAL CONF. OF THE URB AND REGIONAL INFO. SYS. A. 201 (1986).

87. Beard, *Designing GIS to Control the Misuse of Spatial Information*, 1 ANNUAL CONF. OF THE URB AND REGIONAL INFO. SYS. A. 253 (1989). Beard recommends keeping the data updated, documenting any generalization of data, developing methods for representing data quality, and explicitly representing the resolution of the data.

contexts, GIS has the potential to reduce misuse. However, this problem has not been addressed with concerted effort.[88]

C. *Impact on Conflict*

The use of GIS may enhance conflict and litigation since the availability of necessary information will allow decision makers to address questions that were previously unanswerable. Parties to a conflict will have access to information that would have been prohibitively expensive to acquire ad hoc. Access to previously unavailable information may have some negative consequences on the level of conflict and alter the decision process in a dispute. First, access to information may allow more parties to initiate or carry on a conflict. Second, the balance of power among those who control information may be altered. Parties who previously could not win a dispute due to a lack of information and evidence may assert and prove their contentions. Finally, more questions about the impact of the decision will be able to be answered.[89] Therefore, increased information may "fuel the fire" instead of reducing conflict. However, increased conflict may be beneficial and preferable to no decision or one made on an uninformed basis.

A GIS cannot be considered a noncontentious data set to solve all problems between litigants. The creation of a noncontentious data set by a neutral agency for dispute resolution would be contrary to our adversarial system.[90] Our adversarial system allows parties to a conflict to question all evidence presented. Therefore, GIS may not provide measureable savings in time or cost in the resolution of disputes.

VII. CONCLUSIONS

A geographic information system "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."[91] The purpose of geographically referenced information is to make more information available at a lower cost.

Information is essential for making decisions about scarce resources. However, information costs money. Therefore, decision makers may not want to finance an exhaustive search to obtain perfect information. The efficient nature of GIS usage will allow more complete information to be available for decision making.

The automated GIS has three characteristics which make it more efficient to use than conventional paper-based products. First, the GIS is integrated—all of the information is in one place or placed in a distributed network. Second, the information in a GIS is spatially registered to a common coordinate system,

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88. *Id.* at 253-54.

89. Epstein, *The Impact of Information Science on Conflict*, 1 ANNUAL CONF. OF THE URB AND REGIONAL INFO. SYS. A. 308 (1989).

90. *Id.*

91. National Research Council, *supra* note 8, at 14.

allowing comparison of different information. Finally, the information is in a digital format, so that it can be quickly accessed, easily compared, and rapidly updated.

GIS may have great value as an evidentiary tool in litigation. Graphical information such as maps is often used in court. This information is often used only for demonstrative purposes, *i.e.*, to demonstrate the factual contentions so the jury may understand. Non-GIS graphical information specifically prepared for litigation may not be admissible as evidence due to the hearsay rule. GIS information held by a government agency may be admissible as evidence as an exception to the hearsay rule under Federal Rules of Evidence 803(6) and 803(8), the "business records" and "public records" exceptions. Therefore, GIS has an advantage over non-GIS information as an evidentiary tool.

However, the use of a GIS probably will not reduce conflict. In an adversary system such as our own, a party has the opportunity and the right to question information proffered by the opposing party. In addition, information will be available to answer questions which were previously unanswerable due to the cost prohibition of gathering information. Therefore, a GIS may enhance conflict.

The benefits of GIS usage come with costs. Information costs money, and a GIS requires a great deal of it. However, since the information contained in a GIS can be used by a multitude of end-users, the costs can be spread among them to provide information at a lower cost.

GIS is a relatively new technology with benefits which are not yet entirely realized. The databases are still being developed, and the technology is expanding rapidly. Decision makers are at a point where they will derive great benefits from GIS usage in the future.

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