A geographic information system (GIS) is “a computer system for capturing, storing, checking, integrating, manipulating, analyzing, and displaying data related to positions on the Earth’s surface,” according to the Association for Geographic Information, as cited in the Open Geospatial Consortium Glossary.1

Put simply, the use of GIS in real estate enables the user to capture, store, analyze, and visualize real property information data points of interest in a map or geospatial context. GIS makes possible solutions that are impossible to achieve viewing the same data set in a spreadsheet format or without geospatial context. Adding a spatial component to data provides the user with an opportunity to gain greater insight into the data and see new patterns that might be less noticeable in a purely tabular or narrative representation of data.

“GIS brings information together; it unifies and integrates that information,” says Jack Dangermond, cofounder of Environmental Systems Research Institute (ESRI). “It makes available information to which no one had access before, and places old information in a new context.”2

Geographic information systems have, for the most part, been available to real estate practitioners for more than 20 years, with vendor platforms integrating data into various layers. However, the use of GIS by appraisal professionals is still relatively limited in comparison to the advanced valuation applications in tax assessment.

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In recent years, some basic forms of GIS technology and techniques have become more common, especially aerial images and the mapping of data with applications such as Google Earth, Bing, and Yahoo Maps. These applications facilitate the geographic map presentation of comparable sales, for example, against a Google Earth overlay. Often termed mashups, these integrations have been very useful in presenting data effectively from a spatial or GIS perspective.

While these mapping functions have certainly provided a window into the market, they lack more sophisticated mapping functions embraced by other professions such as tax assessors. Applications in tax assessment have been much wider in scale, but many of these applications still do not provide a direct link between GIS and mass appraisal valuation. However, the trend to embrace or leverage new tool sets that resulted in the use of automated valuation models (AVMs) is expected to spur the transfer of GIS technology and techniques in the private sector as well. Assessors were among the first real estate professionals to realize the benefits and potential of the enabling technologies of GIS, focusing on the spatial display of data, and among the first to embrace the technology, as much out of necessity as desire. The use of GIS with public record data became the mechanism for bringing a spatial perspective to data for assessors, which became an analytic tool the assessment community used to manage large quantities of data.

The benefits of embracing enabling technologies from mass appraisal techniques in the private sector have never been more obvious. Current uses range from instantaneous property value indicators that could be reconciled with other approaches to value for lending purposes to portfolio valuations for asset management. The use of CAMA (computer assisted mass appraisal, the assessment community’s term for mass or multiple property appraisal) technology is beginning to permeate all sectors of the valuation industry, from the agricultural sector to the interactive development potential for a highest and best use analysis. Figure 1 illustrates how a GIS layer of the subject property boundary lines is placed over a GIS layer of a map showing wetlands areas using Maptitude GIS software. The areas of the subject property affected by wetlands can be seen clearly.

**AVM, IVM, and CAMA Development**

Within the last 10 years, both the assessment and fee appraisal communities have employed GIS to improve accuracy in property value determinations. A GIS can identify, through mapping and imaging, external geographic influences on a subject property such as the proximity of traffic corridors, i.e., influences that can and do affect property value. For example, a subdivision bounded by both a busy highway and a golf course will experience different effects from these external influences across the entire range of properties within the subdivision. An interactive valuation model (IVM) that incorporates spatial attributes can assist in the valuation of the effect of these influences for all properties in the subdivision.

Geographic information systems can also be used in single-property appraisal. For example, if the subject property is vacant land with a wetland issue, a GIS can help identify soil limitations and provide insight into the development potential for a highest and best use analysis. Figure 1 illustrates how a GIS layer of the subject property boundary lines is placed over a GIS layer of a map showing wetlands areas using Maptitude GIS software. The areas of the subject property affected by wetlands can be seen clearly.

**Public and Private Sector Source Development**

Unlike a traditional automated valuation model system, IVMs allow an appraiser to refine and validate modeling output and neighborhood level analytics, making the final value estimate a truly synergistic collaboration between the appraiser and a valuation model.

While regression-based modeling has been in use for many years on the assessment side of the profession, today both the public and private sectors have IVM/CAMA valuation players. GIS today is primarily used in the public sector as an illustrative, consumer search, or adjustment tool. Combining IVM technology and GIS has been less common. An example of a GIS-based valuation system is the AgriStat system currently used by Farm Credit Services of America. While the public sector has led the private sector in terms of GIS-only
use, it is possible that the private sector will actually solve the “riddle” of creating an IVM/GIS valuation system first because there is a clear need for better analysis tools at the field appraiser level. Combining current appraisal practice with the integrated use of mapping, GIS, Global Positioning System (GPS), and other available technologies could provide a solution for maximum appraisal productivity.

All mortgage transactions link a geographic location to related information necessary to move the loan process forward, and the appraiser is often the independent party who gathers and evaluates information relating to the property. This information commonly includes the legal description, street address, property characteristics, property taxes, and several hundred other data fields. These data points provide vital information of interest to the GIS community.

Today many geographic information systems consist of simple (or complex) layering functions that literally stack visual data sets on top of one another. These “stacks” can be linked, providing interactive functions. For example, a user can draw a shape on one GIS layer, and the system in turn provides data from other layers for the area covered by that shape. Figures 2 through 5 on the following pages demonstrate this functionality and additional analysis using the application Spatialest.

The combination of the layers of data becomes information to the user. This transformation of real estate data into real estate information may provide the key to the linkage of modeling data with spatial analysis through GIS. Most geographic information systems today do not allow for any transfer (in a numeric format) between the GIS screen and the file data. Although some GIS vendors have coded some analytic ability into their systems, the classic model is a two-way pipeline between the regression-based valuation system and the geographic information system.

For example, assume that an IVM is developed for a neighborhood that has a golf course located in its center. The IVM could demonstrably account for all significant valuation attributes concerning the location and physical characteristics of each home, with the important distinction of golf course proximity. Appraisal theory provides indications

![Figure 1 Wetlands Data and Property Boundary](image-url)
Figure 2  Plotting a Property by Location

Find a Property

**By address:**

**State:** CA

**County:** Arcadia

**Zip:** 91006

**Address:** 5623 Lenore Ave

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**From a map**

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[Map of Arcadia area showing property location]
Figure 3  Adding Aerial Map Imaging and Recent Sales Information

Automatically Flags properties that sold greater than 25% of the indicated market value estimate.

Add all recent sales information

spatiallest®

www.spatiallest.com
Figure 4 Adding Foreclosure Sales and Other Data

Apply GIS layer of foreclosure sales

Add properties from appraiser files
that golf courses do affect the value of homes with direct frontage on fairways. The appraiser therefore has only a few options concerning use of the IVM in this neighborhood:

1. Do not use the IVM and perform traditional appraisal procedures.
2. Use the IVM and provide a manual adjustment for the golf course influence based on appraisal judgment.
3. Use the IVM system to develop a base value, and then use the GIS map to provide support for the value adjustment developed manually.
4. Use the IVM model and add a golf course variable to the regression model to account for golf course frontage; manually code the variable based on information from the GIS map; and rerun the IVM with the golf course variable.
5. Use the IVM system and the GIS link to the data in the regression model; click or draw a polygon around properties so that the GIS automatically creates and codes a variable that is then transported into the regression modeling system; and rerun the IVM with the golf course variable.

It is important to note that all five options are integrated appraisal-GIS solutions. Options 4 and 5, however, are integrated IVM-GIS valuation solutions. While the latter options are similar in functionality and outcome, the issue of scale becomes problematic. Option 4 can be used for smaller scale IVMs but quickly becomes impractical for larger scale models with many properties and many GIS influences. Only Option 5 provides a true and practical solution to IVM-GIS integration.

Other paths to GIS integration depend on the scope of work of the assignment and the experience and knowledge of the practitioner. The following sections of this chapter describe integration efforts in other real estate valuation areas.

Other Private Sector GIS Applications
Outside of valuation modeling, GIS coupled with a real estate sales or listings database can assist a buyer or seller in understanding the influences of supply and demand by showing properties that are available and those that have sold. Consumer uses of GIS tools have been popularized by online applications such as Zillow and Trulia, among others. With
newer tools such as Google Earth and other aerial applications, users can understand the context of how, in a macro sense, location affects their properties or properties that they may have an interest in.

**Government Uses of GIS and Valuation**

GIS technology continues to offer many tools to assist the valuation function of tax assessors. While not a replacement for a computer-assisted mass appraisal program, GIS, if carefully developed, can be integrated with a CAMA program and enhance numerous aspects of an assessment practice. Ultimately, the linkage between data and GIS ensures that the interests of the community are served through equitable taxation.

In areas with a large number of property parcels, it is not unusual to find many outliers or exceptions that require extra attention to detail and additional research and verification. A graphical, visual method of displaying the properties makes it easier for assessors to identify potential problems in the appraisal process when dealing with a potential outlier.

GIS also provides useful tools for the assessment process by integrating a variety of factors into the valuation process based on the characteristics of a particular property parcel such as the following:

- Soils
- Comparable sales within a given distance
- Zoning
- Proximity to bodies of water and floodplains
- Area or size
- Transportation access and frontage
- Land use patterns

While assessment is considered here, the transference of this same functionality to the private sector can clearly provide significant benefits to fee appraisers.

**Using GIS to Improve the Modeling Process**

Knowing exactly where a property is located is the most basic GIS application in the appraisal process. Moreover, GIS can be used effectively in the appraisal process to handle large data sets, which lend themselves to use in statistical modeling as well. Mass appraisal has already defined which statistical methods are credible tools in the valuation process, and integrating statistical modeling tools within a GIS-centric environment can make GIS practical and useful to appraisers.

Building a modeling process that fully integrates GIS and mass appraisal requires that location determinations become an explicit part of the modeling process. The GIS software need not be directly linked to the modeling software, but such linkages can streamline the process.

Using GIS to help determine or define market areas can start with the examination of assessor neighborhood maps. Assessors usually build their own internal models using neighborhoods and subdivisions, which normally involve one or more periods of construction, similar property characteristics, one or more builders, and, of course, location.

More sophisticated GIS applications may in fact aggregate many neighborhoods into a few large modeling areas, though it is generally clear that such large-scale applications are less accurate than smaller-market modeling systems. The property grouping process is two-sided: neighborhoods are first clustered by attributes such as age, size, and housing style, and the properties are then grouped geographically by market area.

The clustering process allows the appraiser-modeler to group similar neighborhoods to increase the number of sales. The clustering process also allows smaller neighborhoods with few or no sales to be modeled with larger neighborhoods that have a greater number of sales, in effect mimicking the appraisal process used in traditional single-property appraisal.

Neighborhood-level adjustments occur within the boundaries of the modeling area and the neighborhoods that make up the modeling area. Standard mass appraisal models typically cannot account for locational influences within or adjacent to the modeling area. For example, if a row of homes is located next to a highway corridor, any deleterious valuation impact from this location will not be considered in the valuation model unless a variable representing the location effect is explicitly present in the model. Such a variable would allow the modeler to test for value differences within or adjacent to the modeling area. This analysis process assumes, of course, that sufficient sales exist within the influence area to test against sales not located within the influence area. GIS applications allow for several levels of adjustments, from simple lump-sum adjustments to layered adjustments where the valuation impact follows a gradient away from the location impact. The advantage of GIS is that these location effects can be identified and tested in the valuation model through...
a spatial or visual examination of the data plotted on a map.

The full integration of GIS into mass appraisal modeling requires that GIS-based data be included in and enhance the market sales data set. Ideally, modelers should be able to test and retest for location factors as part of the modeling process. This interaction allows for the complete accountability of location inputs. The GIS information, in effect, refines the modeling data and process. Moving such information from the GIS screen into the modeling data, however, is not easy with many GIS software applications, but with a greater focus on enhancing real estate data, this sort of functionality will likely be available in the near future.

Conclusion

In the future, the integration of GIS information into the mass appraisal modeling process could allow for a complete visualization of the valuation process. Currently GIS data is geographically oriented, allowing for the layering of data and the manipulation of the information stored within those layers. This scenario simply represents one facet of the visualization process. Using GIS fully in the valuation process is likely to result in a flood of new applications and valuation innovations in the not-too-distant future. The Farm Credit application mentioned earlier is one example of the potential for applications that leverage the functionality of GIS with data to provide better and more meaningful analysis for users.

It is clear that a comprehensive valuation system must include at least a location component that is linked to a basic geographic information system. Part of the challenge will be to effectively add GIS to the valuation ingredient list at every point in the valuation process. Mass appraisal models can be built without a formal GIS tool, but without GIS such models have difficulty accounting for significant location effects and phenomena. Adding GIS to this process will have to be accomplished if mass appraisal valuation is to advance beyond regression modeling. Another result of the integration will be the creation of formidable valuation systems that outperform current mass appraisal systems and traditional appraisals because local appraisers, knowledgeable about the market and the valuation process, will be involved in the analysis.

Needless to say, understanding the issues of data are of the utmost importance. As GIS expert Grant Thrall, professor at the University of Florida, states, “It can be said that GIS is 90% data.” Through the incorporation of data with GIS functionality, appraisers can discover much about the markets they are analyzing and provide their clients with a more granular view of the marketplace.

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Web Connections

Internet resources suggested by the Y. T. and Louise Lee Lum Library

Environmental Systems Research Institute, Inc. (ESRI)
   http://www.esri.com

Guide to Geographic Information Systems
   http://www.gis.com

National Center for Geographic Information and Analysis (NCGIA)
   http://www.ncgia.buffalo.edu

Number Cruncher Statistical System (NCSS)
   http://www.ncss.com

Statistical Package for the Social Sciences (SPSS)
   http://www.spss.com

What is Geostatistics
   http://math.arizona.edu/~myers/hompage/whatis.html