PARCEL MAPPING USING GIS

A GUIDE TO DIGITAL PARCEL MAP DEVELOPMENT FOR MASSACHUSETTS LOCAL GOVERNMENTS

Commonwealth of Massachusetts

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Massachusetts Geographic Information System (MASSGIS)

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LIST OF FIGURES

1.0. Introduction

The concept of parcel mapping goes as far back as ancient China, Egypt and Babylonia (Goodwin 1994, 20). In colonial North America, the most common techniques of keeping track of land ownership were surveying and deed registration, but not actual parcel mapping. As a result, prior to 1950 most towns in New England referenced land parcels within the town by Register of Deed’s book and page numbers, subdivision map, or record plan rather than depicted groups of adjoining parcels on detailed maps. Since then, mostly due to increasing property values and rapid development, towns began to realize the importance of having accurate parcel maps and they started to invest in this area (Goodwin 1994, 21).

It is the proposition of this guide, that parcel maps are reference tools and do not replace deeds or record plans and the legal conveyance of a property either by boundary, dimension, or ownership. The utility of a parcel map is that it allows for easy identification of where a property is located relative to public ways and adjacent properties. For planners, assessors, and engineers it provides a construct to aid in the evaluation of proposed subdivision, compliance to local zoning, expansion of municipal utilities, and as a tool for managing the tax assessment process. A parcel map is perhaps the most convenient resource available to the public to determine the location and parcel identification number of a property.

An adequate parcel map should reflect size and shape of each individual parcel owned in a town. Many town officials (assessors, planners, engineers, and others) use parcel maps on a daily basis, that is why it is very important that parcel maps should show the most current and updated information. Development of computer technologies along with geographic information systems (GIS) created opportunities to conduct this work more efficiently. It is much easier to store, maintain and update a digital map than an analog paper map. Digital parcel mapping also simplifies the process of locating the information about any of the parcels and markedly reduces time necessary for making changes and printing new copies of the maps on paper. Digital maps can be connected to computer databases (such as a Computer Assisted Mass Appraisal (CAMA)) that allow access to and maintenance of valid records including valuation, ownership, and description. Digital parcel maps can be integrated into a more general geographic information system that will allow users to maintain and retrieve the record of zoning, land use, conservation easements, etc. Due to increased efficiency of tax map management and the potential for valuable GIS applications, many towns are transitioning from paper to a digital form of parcel mapping.

This document is prepared for the purpose of providing local governments with a comprehensive guide to tax parcel map conversion for use in GIS. All aspects of the conversion process are detailed, including methods, georeferencing, integration with CAMA databases, accuracy standards, and legal issues. Each chapter covers the basic concepts, issues, and methodologies. Software specific instructions are not included, although case studies are presented to illustrate how some Massachusetts communities use a variety of software components. The guide also includes a model request for proposal to aid local governments in contracting for parcel conversion.

Information for the guide was gathered from GIS professionals, assessors, the Commonwealth Department of Revenue, and academics. Links to World Wide Web data sources and references are provided where possible. Procedures for the preparation of hardcopy parcel maps and vendor contracting were based upon guidelines issued by the Commonwealth of Massachusetts Department of Revenue, Division of Local Services.

This guide is prepared for MASSGIS by the University of Massachusetts Office of Geographic Information and Analysis, Amherst, 1999.

2.0. Parcel Mapping Methods

One of the important steps in creating digital parcel maps is conversion of traditional paper maps (or analog maps) into digital GIS data layers. Not only do the data have to be transferred into a digital form, but they also have to be vectorized so that GIS software would be able to distinguish between individual elements such as lines, points, and polygons. There are several ways to do this:

- Manual digitizing from analog maps;
- Scanning with further “heads-up” digitizing or automatic vectorization;
- Coordinate Geometry conversion (COGO);
- Positioning property corners with GPS.

2.1. Manual Digitizing from Analog Maps.

This is the most basic method of digitizing traditional paper maps. Manual digitizing is done by placing a paper map on a digitizing board and entering all the elements of the map into the data base by means of a sensitive digitizing puck. An operator enters data by placing the digitizing puck over the points on the map attached to the digitizing board and pressing different buttons on the puck, thus indicating the type of each point. A point can be either an individual element, or a part of a larger element such as a line or a polygon. Lines and polygons are still defined by a set of points entered by an operator and connected by lines (vectors). Therefore, the accuracy of the data depends of the accuracy of the location of the points. In the case with lines and polygons, the more points entered, the smoother the curves of the line will appear (see Figure 2.1).

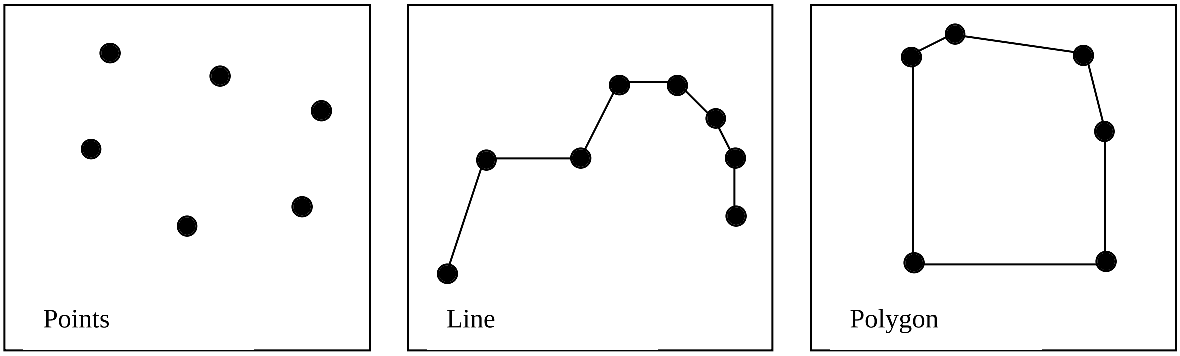

Figure 2.1: Elements of digital GIS data layer.

Digitizers are capable of providing a very high degree of accuracy in defining the location of each point (as high as 0.002” to 0.005”). Still, the accuracy of the data depends to a great extent on the accuracy and skills of the operator who manually enters the points by means of the digitizer. Usually, after all the data have been entered, it is necessary to edit them in order to get rid of operator’s mistakes. Such mistakes are usually of two kinds – undershoots and overshoots. They result from the difficulty for an operator to control the precise location of a puck on the board and because the width of the lines on the paper map is sometimes much wider than the accuracy of a digitizer. Those mistakes can later be noticed when the data layer is displayed at a greater scale on a computer monitor (see Figure 2.2).

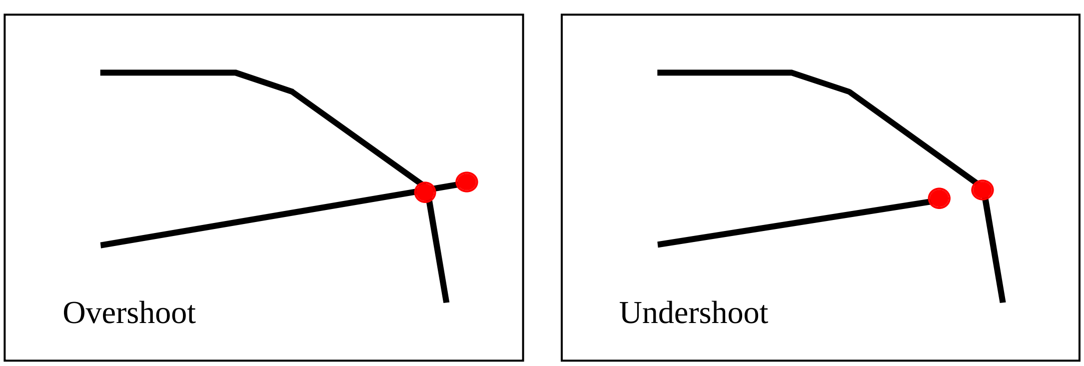

Figure 2.2: Common mistakes of manual digitizing.

Accuracy of the digital data also depends on the accuracy of the analog map. If lines on an analog map are misplaced, the operator will be able to correct them only to a certain degree. It means that most of the analog map inaccuracies will be very accurately reproduced on a digital map.

Manual digitizing has its own advantages and disadvantages. In GIS Guidelines for Assessors prepared by Urban and Regional Information Systems Association and the International Association of Assessing Officers (IAAO and URISA 1992, 37-38) the following advantages and disadvantages of manual digitizing are listed:

Advantages:	Disadvantages:
· The ability to correct errors or distortions in the original maps at the time of data capture. · Highly reliable human recognition of map objects. · The ability to interpret ambiguous or incomplete information and select the relevant required information at the time of data capture.	· The process is labor intensive and therefore very time-consuming and costly. · The quality of results is highly dependent on the operator experience. · The results may be inconsistent due to varying operator conditions, stress, and fatigue.

2.2. Scanning

The second method of parcel data conversion is scanning. In order to be scannable, a parcel map should be in a very good condition with minimum text on it. Hardcopy parcel maps are converted to digital form using a scanner. A scanner recognizes the black or white value of each pixel location on a map. Values are assigned across the whole map creating a raster image of the map (IOAA and URISA 1992, 39).

Raster format is not very useful for many GIS applications. A raster image is simply a picture and can not be manipulated by the user in ways that tax maps are often used. In order to be able to edit or update the map it is necessary to convert the raster image into a vector one. There are two methods that could be used for this purpose: automatic vectorization and heads-up digitizing. Depending on the method to be used for vectorization, appropriate scanning resolution should be chosen. Most vectorization programs require that lines be at least three pixels wide in order to be reproduced as vectors. A typical hand drafted line in pencil is about 0.018”. In order to automatically vectorize such lines, it is necessary to use at least 200 dpi (dots per inch) resolution, but 300 dpi would be better. A line drafted in ink or fine point pencil is about 0.012” and will require resolution about 400 dpi (Litton 1998, 1). If heads-up digitizing is to be used, scanning at high resolution is not necessary and a good quality map could be scanned at 150 dpi or even 75 dpi depending on the size of the source map and whether you want to zoom in for significant enlargement of the image.

2.2.1. Automatic Vectorization

This method could be used only if a map is in a very good condition – all lines are clear, have similar thickness, and clear intersections, and if there is no annotation or unnecessary features on the map. If this is the case, then the software can trace all the lines on the map and it would leave little editing to perform afterwards. This is the easiest and quickest method of parcel data conversion, but, unfortunately, parcel maps are usually not in pristine condition and have all types of different features and text on them. Vectorization software can not identify features (for example, it can not distinguish a water body from a parcel line), and most types of vectorization software can not distinguish text from lines. If a map cluttered by many different features is vectorized, it will require a lot of editing afterwards to delete all extra features and annotation. Time spent editing such a map could easily overweigh time spent on map conversion done by some other method. To minimize editing required after vectorization, it could be necessary to manually redraw a parcel map on Mylar selecting only parcel lines and thus excluding all extra features and annotation.

This method has certain advantages and disadvantages.

Advantages:	Disadvantages:
· Could be very fast and cost effective · Relatively inexpensive · Provides a very accurate representation of the analog map · Easy	· False recognition of different features and text · Editing could be very labor intensive · The analog map needs to be in a pristine condition with minimum extra features and annotation

Figure 2.3: Advantages and disadvantages of vectorization
Source: Barnett, Goodwin 1994, Struck 1998.

2.2.2. Heads-up Digitizing

This method is usually used when the analog map is in a very bad condition and when the digitizing board is not available. Heads-up digitizing involves manually tracing the lines on a computer screen over the top of the scanned raster image. The raster image is used as a background image. Everything that was said about on board digitizing could be applied to on screen digitizing as well. There are several advantages of this method over on board digitizing:

1. Several people can do on-screen digitizing simultaneously because this work could be distributed between several computers, whereas it is very seldom that an organization would have several digitizing tables;
2. Heads-up digitizing is not as tiring as a board digitizing because an operator remains in a seated position, whereas on-board digitizing requires an operator to be in a standing position all the time.

Source: Barnett, Goodwin 1994; Struck 1998.

2.3. Coordinate Geometry (COGO)

This is a more accurate method of parcel data conversion to a digital form than any of the methods mentioned above. COGO uses a completely different approach to the process of data conversion compared to digitizing or scanning. The difference is that the analog map is not involved, but land surveys and deeds are used instead. Land surveyors' record information about each individual parcel in terms of geometric distances and angles from control points (benchmarks). The COGO procedure involves entering into computer such information as a precise starting coordinate, the direction and distances of each side of the parcel. After that, the computer performs some calculations to create a geometrically accurate parcel polygon. Unfortunately, not all parcels have property boundary descriptions or the information could be wrong. Therefore, it is often necessary to go out in the field and collect the missing information or verify the existing documentation.

COGO also has its own pluses and minuses.

Advantages:	Disadvantages:
· Provides an excellent positional and dimensional accuracy · Provides a check on the closure (should start and end at the same point) and surveyed area of each parcel · It is not necessary to have a hardcopy parcel map	· The most time consuming method · Very labor intensive · Very costly · Deeds for all parcel must be accessible

Figure 2.4: Advantages and disadvantages of COGO
Source: Goodwin 1994; Gresavage and Thomas, Struck 1998

2.4. Positioning Property Corners with GPS

The property corners of many surveyed and platted parcels are usually marked with iron pipes or nails. If coordinates of these markers are somehow obtained and input into GIS software, it would only be necessary to connect the dots in order to get a very accurate parcel map. The resulting accuracy could surpass even that of COGO (Struck 1998, np). Today, with the rapid development of the Global Positioning System (GPS) , it has become relatively easy to get coordinates for the property corners. In order to obtain coordinates, two different strategies could be used: static positioning or kinematic positioning (Struck 1998, np).

The choice of the strategy depends on the needs and available resources. Static method provides better accuracy (down to one centimeter) but it is more time consuming, as it requires longer standing time at each point in order to get an accurate reading. The kinematic method is less accurate (accuracy +/− 1 to 10 feet) but, on the other hand, it is less time consuming. Satellite readings are obtained almost immediately as you walk from one pipe to another (Struck 1998, np).

Advantages and disadvantages of this method are summarized in the table below.

Advantages:	Disadvantages:
· Provides the best accuracy · No guesswork · All questions are resolved in the field, not in the office · Analog map is not required	· Obstacles can block or reflect satellite signals · Very labor intensive · Time consuming · Requires training

Figure 2.5: Advantages and disadvantages of using GPS

2.5. Transferring of Existing CAD Maps

CAD (Computer Aided Design) maps appeared in early 1980s (Nale, 3). CAD enabled users to provide much more precise drawings in comparison with hand drafted maps. CAD uses actual parcel dimensions to generate digital parcels. However, capabilities of CAD systems typically do not go beyond simple map production – they do not support sophisticated queries or analysis. By 1988, topology and buffer generation, thematic mapping, network analysis, feasibility studies, forecasting, etc. became possible with the help of geographic information systems software (Nale, 3). In the past, many organizations have digitized their parcel maps using some drafting packages such as AutoCAD or MicroStation. Now, when they want to make a transition to GIS, the question is whether they can make use of the CAD drawings. Generally, CAD drawings do not comply with strict specifications that GIS coverages require. For example, lines that should be connected are very seldom “snapped” together, maps are rarely projected

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How Global Positioning System works will be discussed in the next section.

into a proper coordinate system. Nevertheless, if the maps are accurate and depict current information, they could be translated into GIS software. Translation is “the process in which graphic images are taken from one software package, formatted into another structure, and input into another software package” (Flodmark, p. 3). After the process of translation from CAD to a GIS format, it will be necessary to edit and project the coverage. Vector information (lines) usually translates well, but annotation and attributes very often get lost or altered in the process of translation (Struck 1998, np). Another reason why existing CAD drawings should not be disregarded is the fact that they are already in the digital form and they only need to be imported and edited.

2.6. Example of Analog and Digital Parcel Maps

Figure 2.6 Analog Parcel Map

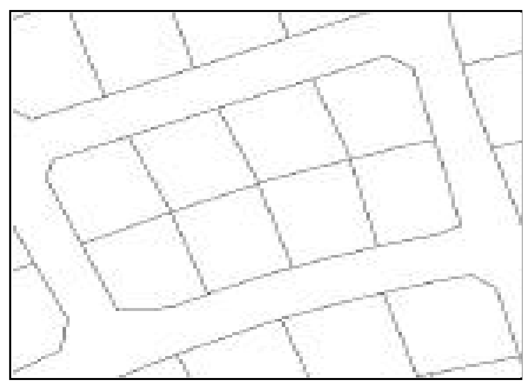


Figure 2.7 Digital Parcel Map

Figure 2.6 illustrates scanned analog map. Apart from parcel lines, it also shows parcel numbers, acreage, parcels dimensions, street names, and other features. Figure 2.7 shows the same parcel map, transferred into digital form by means of digitizing. This map shows only parcel lines. All other parcels characteristics could be added to the attribute table associated with the map and optionally shown on the map.

2.7. Data Formats

Each GIS software has its own data format. In some cases this format could be used to transfer GIS data from one computer to another, in other cases it is necessary to create a special export format, and then import it into the target system. Common formats to transfer GIS data are summarized in the table below (Hohl 1998, 180-181).

Format	Description
AutoCAD drawing exchange format (DXF)	A vector format that has become the de facto standard for transfer of data between different CAD systems. Often used to transfer geometry into and out of GIS systems. DXF is not well-suited for transferring attribute data.
ARC/INFO export format (e00)	A vector format intended to transfer data, including attributes, between different ESRI systems. Despite being a proprietary format, there are other GIS systems that can read or write e00 formats.
ArcView shape file format	Openly published, this vector format is available for use by other GIS vendors. It consists of three types of files: main files (SHP), index files (SHX), and dBASE tables (DBF) for storing attributes.
MapInfo interchange format (MIF/MID)	This format, also formally proprietary, has nonetheless been widely implemented in other GIS systems. MIF files store vector graphical information, while MID files store attribute data.
MicroStation design file format (DGN)	An openly documented vector format used by Bentley's MicroStation CAD software. MicroStation is the platform on which the Modular GIS Environment (MGE) and MicroStation Geographics GIS packages are built. The format doesn't store attribute data, but can store links to relational database records. MGE and Geographics also have export formats that transfer all files and database tables associated with a project.
Digital line graph (DLG) format	A vector format used by the U.S. Geological Survey (USGS), and to a lesser extent, other federal and state government agencies. DLG format only supports integer attribute information for spatial objects.
TIGER/Line format	The format used by the Census Bureau to distribute vector and attribute data from its Topologically Integrated Geographic Encoding and Referencing (TIGER) database.
Spatial data transfer standard	A standard format used by the USGS and other federal agencies, designed to support all types of vector and raster spatial data, as well

(SDTS) format	as attribute data. The Topological Vector Profile (TVP) and the Raster Profile are implementations of subsets of the SDTS.
Tagged image file format (TIFF or TIF)	A raster format frequently used for imagery, GeoTIFF is an extension to TIFF that includes georeferencing information.
Joint photographic experts group (JPEG or JPG) format	Another raster format commonly used for imagery.

Figure 2.8: Data formats

2.8 Selection of the Best Conversion Method

The choice of the particular method of parcel data conversion depends on the availability and quality of the source maps, availability of the specialized software, and the requirements for quality and completeness of the data vs. the cost of the project. Before initiating the process of conversion, one must evaluate the availability and quality of existing maps. Some of the questions that have to be asked are (Donahue 1994, 8):

1. Were the maps originally drafted from deeds, surveys, and subdivision plats?
2. Do the original land base and parcel maps meet the GIS accuracy requirements (see Sec. 6.2. Accuracy)?
3. Have the maps been maintained on a regular basis?
4. Do the current maps visually edge match?
5. Are the current maps drafted at an acceptable scale?

If the answer to any of these questions is "no", it might be necessary to recompile the paper maps before starting the process of conversion or use a method that does not require the analog map.

Kevin Struck (1998) in his document also suggested a quick questionnaire for organizations in order to choose the best method:

1. Exactly how much money do you have to spend on the project?

   Enough 1 Little 0

2. How many employees do you want to allocate to it?

   Enough 1 Few 0

3. What level of mapping expertise does your staff have?

   High 1 Limited 0

4. How accurate is your control monumentation and how well does it cover your project area?

   > 50% 1 < 50% 0

5. Are a significant number (50% +) of your parcels platted or surveyed, and are these records legible, complete, and acceptable by modern surveying standards?

   Yes 1 No 0

6. Are the parcels for your entire municipality mapped in a legible, complete, and up-to-date hardcopy format?

   No 1 Yes 0

7. Are all parcel legal descriptions readily available?

   Yes 1 No 0

8. What is the quality of the legal descriptions? (Is there a small percentage of descriptions with indefinite dimensions, vague point of beginnings, and traverse closure errors?)

   Good 1 Poor 0

9. Do you have large areas of irregular parcels such as French long lots and Government Survey Lots?

   No 1 Yes 0

10. What kind of equipment do you have? Digitizer or Scanner? COGO software?

   COGO 1 Digitizer or Scanner 0

If you got 7-10 points, the best method for you is COGO or GPS, if you got 0-4 points, you should use digitizing or scanning, if you got 5-6 points, it is not clear what method is the best for your organization. If the organization doesn’t have enough time, skilled personal or special equipment, the best thing would be to higher a subcontractor to do the parcel conversion work. For more information about outsourcing versus in-house operation see Sec. 10.0. of the report.

3.0. Georeferencing

A crucial element of any parcel mapping project is registering a parcel map with the correct real world coordinates. This procedure is called georeferencing. If the parcel maps are not georeferenced, no other information can be displayed over or positioned under the parcel map coverage. Georeferencing could be done either before or after the process of parcel data conversion. There are two groups of methods that could be used for this purpose depending on source materials available in each particular case:

1) Registration to a coordinate system; and
2) Registration to a base map

3.1. Registration to a Coordinate System

3.1.1. Use of Existing Coordinates

The first method of digital parcel map registration is to use the known coordinates. Currently, most of the towns in Massachusetts have their parcel maps in the form of large blueprints that were originally either hand drafted or done in Auto CAD. Some of the towns may even have coordinates displayed in the corners of individual parcel maps. It is likely that these coordinates are in Massachusetts State Plane Coordinate System, North American Datum (NAD) 1927 or NAD 83. If they are in NAD 27 Datum, after parcel map registration it is necessary to transform the map to NAD 83, which is a standard for Massachusetts. To use the known coordinates is the easiest way to register the map. If the known coordinates are used, maps line up precisely.

3.1.2. Use of Artificial Coordinate System

Unfortunately, not all towns possess tax maps registered to a known coordinate system. In such cases, artificial coordinate systems are frequently used. One way to create such a coordinate system is to assign the lowest corner a (0,0) coordinate and then calculate coordinates for all other corners of each parcel map on the basis of the distance from the original (0,0) point.

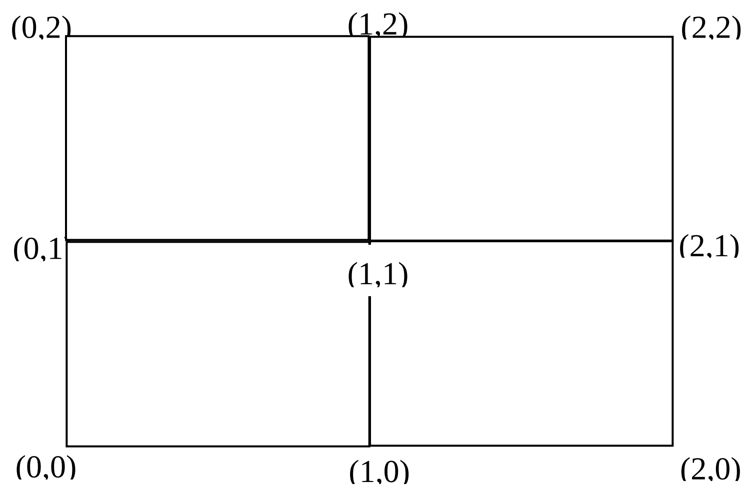


Figure 3.1: Artificial coordinate system construction

A parcel map created by this method will not be registered to any real world coordinate system but the distance between any parcels on the map will be accurate relative to each other. Afterwards it will be possible to register this map to some existing coordinate system or to a base map.

3.1.3. Use of GPS Technology

Another way to create the coordinate system for the town is to use Global Positioning System (GPS) technology.

GPS is a “navigation and positioning system developed by the U.S Department of Defense for use by U.S and Allied military forces” (Land & Mapping Services, p. 1). However, GPS very quickly expanded to non-military applications and now it is used by water and air navigators, geographic surveyors, mappers, geologists, archeologists, forecasters, and many others. Through latitude/longitude or some other coordinate system, GPS can determine the location of the GPS receiver.

GPS works in the following way. There are 24 satellites 11,000 miles above the Earth that transmit orbital position information, current time, and error corrections. In order to determine the location taken at GPS receiver position, it is necessary to receive signals from four satellites. The GPS receiver interprets these signals and determines the distance between the receiver and each satellite. The distance is calculated by multiplying the speed of the signal by the amount of time it took the signal to travel from the satellite to the receiver. Now for each satellite the receiver can plot a radius, with the satellite as a center. The point where all radii intersect, is the GPS receiver’s location. (Red Horse Technologies, 1998, 1-2).

GPS receivers differ among each other depending on the accuracy they produce and their cost. It is possible to distinguish three types of GPS devices depending on their use:

1. The most basic GPS receiver – “handheld” unit. Provides accuracy of several hundred feet.
2. Professional, “mapping” grade receivers. Provide accuracy of several feet.
3. “Survey grade” or Phase based receivers. Provide accuracy of several inches.

Source: Land & Mapping Services, p. 2-3.

There are several factors that can affect accuracy of the GPS readings:

1. Equipment error.
2. View of the sky may be obstructed by trees and other objects.
3. Signals may bounce off the buildings, mountains, etc.
4. The Department of Defense may turn on “selective availability”, which is an intentional clock error introduced into the timing signals.

One of the GPS applications is parcel mapping. GPS may be used to determine coordinates of easily identifiable positions on a parcel map (such as road intersection, property corner, etc.). In order to register a parcel map to real world coordinates it is necessary to have at least four coordinates. But in order to achieve greater accuracy usually it is better to have more than four coordinates. Another issue is the placement of the coordinates – if all four or more coordinates are concentrated in one corner of the map, it will be possible to register the map, but all other corners will be skewed and accuracy of the map will be very low. The choice of the number of coordinates in each case depends on the shape and complexity of each particular parcel map. In general, however, the more coordinates are used, the more accurate the final map will be.

There are certain benefits of this method of parcel maps registration:

1. It is inexpensive
2. It is easy to use
3. It is not time consuming relative to other methods
4. It is not labor intensive
5. It is accurate

3.2. Registration to a Base Map

A base map is "…the graphic representation at a specified scale of selected fundamental map information … (that) provides a primary medium by which the locations of cadastral parcels can be related to … major natural and man-made features such as bodies of water, roads, buildings and fences…" (National Research Council, 1983 in Goodwin 1994, 16). Several types of sources may be used as a base map. This includes orthophotographs, and already existing maps, such as road network maps, and topographic maps.

3.2.1. Use of Orthophotographs as a Base Map

An orthophoto is an aerial photograph that is geometrically correct. On an orthophoto inaccuracies due to displacement, distortion, aircraft movement, and camera tilt are removed via the process of orthorectification, rendering surface features with great accuracy. A normal aerial photograph does not show all features in their correct location (see Figure 3.2)

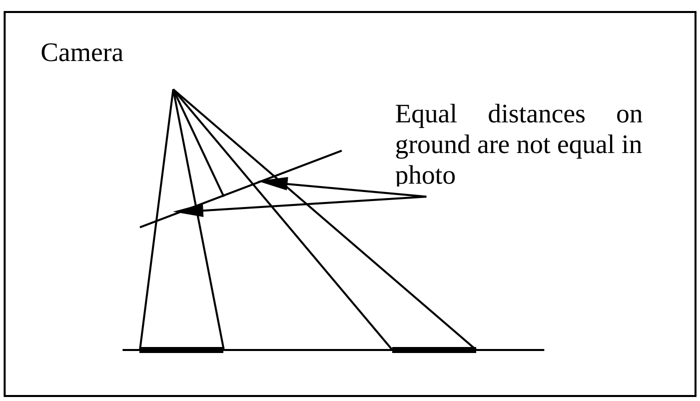


Figure 3.2: Displacement in an aerial photograph
Source: OGRIP, p. 3

Orthorectification removes the distortion as shown in Figure 3.3.

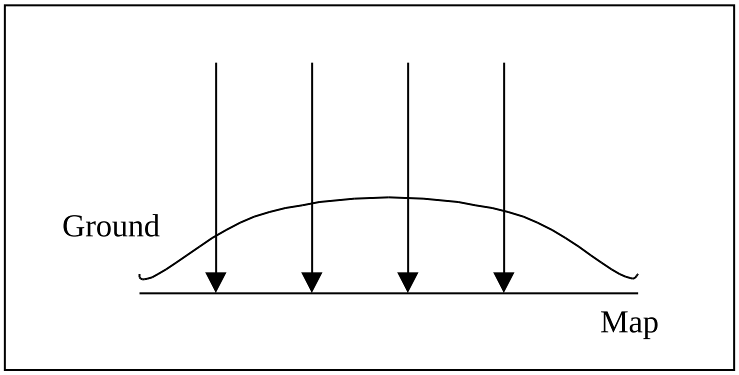


Figure 3.3: Orthorectification
Source: OGRIP, p. 3

One of the uses of orthophotos is in parcel mapping. “Orthophotos make excellent bases for cadastral and tax mapping” because they “…include faint and often intermittent linear features, such as lot boundaries, cut lines through woods, field lines, fences, etc., that are helpful when locating original property lines” (Thrower and Jensen 1976 in Goodwin 1994, 20).

The most important characteristics of orthophotographs that affect their use are scale, accuracy, and resolution. In the case of the hard copy orthophotos, final representation scale determines resolution and accuracy of the displayed features. In the case of digital orthophoto, scale can be changed, but resolution (pixel size) limits what features can be seen when scale is increased. In general, the larger the scale of the orthophoto, the better its resolution and accuracy (OGRIP, p. 4).

Figure3.4: Orthophoto scale, resolution, accuracy, corresponding parcel size and cost
Source: OGRIP, p. 11, 16.

Scale	**Ground Resolution (Pixel Size) in Feet**	**Accuracy in Feet**	**Parcel Dimension in Sq. Feet**	**Cost per square mile**
1:4,800 (1”=400’)	1-2	10-15	208.7	$125-$165
1:2,400 (1”=200’)	1	3-5	60	$260-$350
1:1,200 (1”=100’)	0.5-1	1-3	30	$750-$1,000

After scale and cost, timing of flights is also important. For parcel mapping purposes "leaf off" aerial photography acquired in the fall or spring (before or after snow cover) during the middle of the day is preferred (OGRIP, 8). As for the choice between black and white vs. color imagery, for most parcel mapping situations, black and white data should suffice (OGRIP, 9).

Both digital and hardcopy orthophotographs can be used as a base map.

3.2.2. Hardcopy Orthophotos

Hardcopy orthophotos can be made either on paper or on Mylar. Mylar is a more stable medium as it is not affected by moisture or temperature that could cause stretching or shrinkage of the paper maps. First, it is necessary to recompile the parcel boundaries to the orthophoto. One way to do it is to use a cartographic instrument called a Zoom Transfer Scope (ZTS) or similar type of device. ZTS uses lenses, mirrors, and light to change the scale of one map (or photograph or image) so that it would be possible to superimpose it on another map (in this case orthophotograph) (Goodwin 1994, 44). When the transfer of the parcel boundaries to the orthophoto is complete, it is necessary to georeference the data. The coordinate system associated with the orthophoto can automatically be used for this purpose. If no coordinate system is associated with the orthophoto, it is necessary to choose at least four points easily recognizable both on the orthophoto and on the ground for each orthophoto and obtain coordinates for these points by use of GPS or some other method.

3.2.3. Digital Orthophotos

Digital orthophotos have several advantages over hardcopy ones. First of all, they are not subject to shrinkage and stretching thus giving a better accuracy. Second, they are already georeferenced. Thus the problem of obtaining coordinates for registration points doesn't exist. Third, they are easy to store. Finally, they offer an opportunity to use different methods of parcel conversion. One of the methods is heads-up digitizing directly from the orthophoto. In this case, assuming the orthophoto is already registered to a correct coordinate system, these coordinates could be used for the parcel coverage. Another method is scanning tax maps. In this case, an orthophoto may be used as a source of ground control points also common to the scanned images. Using these coordinates, scanned images may then be converted to the same coordinate system as the orthophoto. After that either heads-up digitizing procedure or vectorizing could be used (Torres, 4-5).

3.2.3.1. Example of Digital Orthophoto

Figure 3.3 gives an example of the 1-meter pixel resolution digital orthophotograph. This orthophoto is a portion of the bigger image downloaded from MassGIS web site: http://www.state.ma.us/mgis/ftpintro.htm

Figure 3.4: Digital Orthophoto.

3.2.4 Sources of Orthophotography in Massachusetts

In 1989 Massachusetts Department of Environmental Protection made a decision to produce orthophotoquads at a scale of 1:5,000 (1"=417') (Goodwin 1994, 18 and MassGIS). This decision was based upon the state's interest in very accurate wetland mapping as well as providing highest resolution base maps for a wide variety of larger-scale uses. At this time only around 35% of the state is covered by this type of base map. Statewide coverage is expected to be completed in the next three years. The maximum displacement of well defined features on these orthophotos is less than 5 meters. Each pixel in the digital orthophoto images represents 0.5 meters on the ground. Each image has been resampled at 1, 2, and 5 meter resolutions. The status map showing communities for which digital orthophotography has already been completed could be accessed at MassGIS web site at http://www.state.ma.us/mgis/st_oq.htm.

MassGIS contact information:

Julie Sweitzer, Program Coordinator
20 Somerset St. – 3rd Floor
Boston, MA 02108
Phone: (617) 727-5227 x323 Fax: (617) 227-7045
E-mail:julie.sweitzer@state.ma.us

Other contacts:
Data and map orders (status and information): Greg Scott, ext. 327
MassGIS Data Viewer: Aleda Freeman, ext. 326
MassGIS Database/Orthophotos: Michael Trust, ext. 322

Another possible source of existing orthophotography could be local utility companies or U.S. Geological Survey (USGS): http://www.usgs.gov/. If none of these sources has orthophotography of required resolution for the particular area, it may be necessary to schedule a flight and produce a new set of orthophotographs. This will, however, add considerable cost to any project.

4.0 Core Parcel Attributes

Most information handled by government is land and parcel related, so the parcel data is important in an urban or county information system. “The parcel layer relies heavily on the base map and on the measurement data in legal descriptions. Once in operation, other transactions relate to the property layer itself, rather than its precursor layers. Building applications, land transfers, emergency response, as well as assessment functions, all rely on this layer.” (Donahue 1994, 240)

There are several attributes that can make up the discrete parcel layer, that is, the basic layer that does not include the assessment information. The most important of these layers is the unique parcel identifier:

· **Unique parcel identifier(UPI)** (also, unique cadastral identifier, See Section 7.3.5) Every parcel needs to be assigned a unique identification number. The system for assigning this number should be legally defined and recognized by official entities as the primary reference for the individual parcel to all data and documents. Secondary parcel identifiers may be assigned for indexing per the needs of individual departments, but they all must be cross-indexed to the UPI. This connection between secondary and primary identifiers allows for multiple uses of the data.

Parcel identifiers should have the following characteristics:

Uniqueness
Permanence
Simplicity
Ease of maintenance
Flexibility
Reference to a geographic location

(IAAO 1988, 10)

It is ideal for the parcel numbering system to be economically implemented, structured for cost-effective maintenance and accessible for all users. With current GIS technology it is not necessarily crucial that the parcel identifier be tied to a specific geographic location (as stated above).

(Donahue 1994, 237)

Figure 4.1 Characteristics of parcel identifiers

Parcel identifiers fall under one of three categories: location, name-related, and alphanumeric. A location identifier denotes the location of the parcel such as is used in map-based, geographic coordinate, and rectangular survey identifier systems. In the map-based system, the map, block and parcel numbers of the assessment maps are incorporated into the parcel identifier. This system is not recommended for areas of rapid development. The geographic coordinate system locates a point on the surface of the earth based upon "its distance from each of two intersecting grid lines known as x and y axes." (IAAO 1988, 10) X and Y coordinates are used in the parcel number, usually reflecting the center of the parcel. This system, once understood, is simple, easy to maintain and upholds criteria of permanence and uniqueness.

- Location
  - Map-based
  - Geographic coordinate
  - Rectangular survey
- Name-related
- Alphanumeric

Figure 4.2 Types of parcel identifiers

The third locational system is the rectangular survey system. It is more common to the Midwest and Western states. It bases the numbering schema on the US Public Land Survey System (PLSS). Township, range, section, quarter-section and quarter-quarter-section numbers, in addition to individual parcel identifiers are used to create the UPI in this system.

In the name-related identifier system of creating unique parcel identifiers, the names of individuals claiming ownership or interest in a parcel are used. The third type, alphanumeric identifiers, is composed of random numbers associated with each parcel. An index of tracts numbered sequentially is an example of a numbering system that uses this type of system. (IAAO 1988, 10)

The city of Boston uses a ten-digit number as its unique identifier. Included are the Ward, Parcel and Subparcel identification numbers (See Figure 4.3). Amherst, another Massachusetts's community, uses the Section, Block and Lot numbers in its UPI.

	Boston		
Name	**Description**	**Type**	
Parcel_id	Each Parcel of Property in he City of Boston is assigned a unique 10 – character identifier consisting of a ward, parcel, and subparcel identification number. (0300275000) Example: Ward=(03), Parcel=(00275), Subparcel=(000)	character	

Figure 4.3: Boston's parcel I.D. configuration (Boston 1996)

Additional core attributes include those that describe survey information:

This information is sometimes included within the unique parcel identifier. Despite incorporation into the UPI, it also usually exists as separate fields of the core parcel attribute database.

- Type (example: cadastral)
- Lot number
- Block number
- Township number

And others:

Supplemental information, such as those items listed below, are sometimes included in the core parcel database, although some of them may reside primarily in the tax assessor's database. Inclusion as a *core* parcel attribute depends on agency needs, in-house and GIS enterprise applications.

- Plan (example: 71724 CLSR BC)
- Street address
- Status (example: Active)

- Legal description (example: Lot 122 Plan 71724 CLSR)
- Area
- Area unit (example: Hectares)
- Perimeter
- Ownership
- Deed reference #
- Plat reference #

Layer Name	Type	Color	Description
10 Ease	Line	17	Easement Boundaries
10 Road	Line	7	Road Right of Way
17 Ease	Text	17	Easement Text
17 Road	Text	3	Road Name
20 Parcel	Line	2	Parcel Boundaries
20 Plat	Line	11	Previously Platted Boundaries
21 Dist	Text	4	Parcel Boundary Distances
22 Bear	Text	5	Parcel Boundary Bearings
24 Area	Text	5	Parcel Areas (in acres)
25 Temp	Text	252	Temporary Construction
25 Temp	Line	252	Temporary Construction
26 ID	Text	6	Parcel Identification (key) Number
27 Name	Text	3	Subdivision Name
28 Legal	Text	1	Legal Description Text
29 Note	Text	3	Miscellaneous Text
30 Forty	Line	11	Quarter/Quarter Section Lines
30 Quarter	Line	11	Quarter Section Lines
30 Section	Line	11	Section Lines
31 Dist	Text	7	Section Line Distances
32 Bear	Text	7	Section Line Bearings
33 PLSS	Shape	5	Section Corner Monuments
34 Area	Text	7	Section Areas (in acres)
37 Name	Text	7	Section Identification Text
40 Meander	Line	4	Meander Lines

Figure 4.4: Sample parcel attribute table (Land 1999)

5.0. Case Studies

5.1. Town of Amherst

In November 1998, the town of Amherst started working on Photogrammetry and GIS Base Mapping project. The implementation of this project was subcontracted to engineering company Merrick & Company, Aurora, Colorado. The first stage of the project includes production of the color aerial photography of the town at the scale

1”=400’ to meet the requirements of 1”=40’ scale horizontal accuracy (± 1.0’) and 2’ contour vertical accuracy (± 1.0’). Also, for an outlying watershed area 1”=800’ scale will be used to meet 1”=100’ horizontal accuracy (±2.5’) and 5’ contour vertical accuracy (± 2.5’) requirements. To perform the photo control, the advanced GPS technology will be used. The approach will take advantage of the existing 75 survey control points. After Airborne GPS and Fully Analytical Triangulation, a photo type Digital Terrain Model, Planimetric, Topographic and Ortho Image databases will be created. The resulting orthophotos scale will be 1”=100’ with 0.5’ pixel size. The next step will be creation of the parcel coverage. For this purpose the “best fit” parcel automation technology will be used. First, the existing Assessor tax maps will be registered to the digital orthophotography. Then, the parcels will be digitized using the landbase as the controlling source. In this approach, the technician will use ground evidence to register the property boundaries. Fence lines, hedge rows, building outlines, ditch lines, lakes, and streams would be utilized to help determine parcel boundaries. The technician will make an adjustment of the block of parcels to the ground evidence (landbase) and then digitize them.

The following features will be converted:

- Street Rights-of-Way
- Railroad Rights-of-Way
- Easements (if shown)
- Subdivision Boundaries
- Hydrology – (Creek, Stream or River lines along parcel boundaries)
- Parcel Boundaries
- Lot lines
- Parcel Centroids
- Town Boundary Lines

The following items will be included as text annotation:

- Town Limit Designation
- Parcel Number (PIN)
- Water Body Text
- Power Line Text
- Street, Road, Highway Name
- Legal Dimensions (Lot Dimensions and Deed Area Text)
- CAMA Linkage Number

Source: Merrick & Company report

5.2. Town of Boylston, MA

In 1998 the town of Boylston as a part of Master Plan update had its parcel maps converted to the digital form. It was done by the Central Massachusetts Regional Planning Commission (CMRPC). The first part of the process was georeferencing of the paper maps. Control points were derived from orthophotos. Anywhere from four to ten control points were used for each map. Usually points that were very easily identifiable on both maps (analog and orthophotos) were used. For example, road intersections, political boundaries, power lines, etc. However, orthophotos covered only three fourths of the town. So, in the areas where orthophotos were not available GPS coordinates were taken and these points were utilized for georeferencing purposes. Anywhere from nine to twelve points were taken for each map sheet.

When the georeferencing procedure was completed, maps were digitized using the software Carta Linx produced by Clark Labs in Worcester. The creation of the digital parcel layer consisted of the two steps. First, roads were digitized from orthophotos, which were used as a background image. Second, parcel lines were digitized from paper map sheets, and manually coordinated in their placement. In those cases where it was possible, parcel lines were digitized from orthophotos. For the portion of town not covered by orthophotos a different method of conversion was used. These maps were scanned by MassGIS Executive Office of Environmental Affairs in Boston and then vectorized. After that, these maps were imported into Carta Linx and incorporated into the greater coverage.

After digitizing was completed, the following attribute fields were created using ESRI ArcInfo software:

1. Area (created by ArcInfo)
2. Perimeter (created by ArcInfo)
3. Map identification number (created by ArcInfo)
4. Map number
5. Block number
6. Lot number
7. Combined map-block-lot field
8. Count (created by ArcInfo)
9. Field containing the Boylston Assessor's Landuse Data as represented in the 1993 Assessors Land Use Codebook
10. Chapter 61 field – depicts Chapter 61 (Agriculture), Chapter 61A (Forest), and Chapter 61B (Recreation Use Areas)
11. Field indicating errors on the parcel sheet (f.e. parcels without block numbers or duplicate numbers on the same sheet)
12. Landuse code
13. Field showing parcels used for recreational purposes including water-based recreation, spectator recreation, and participation recreational areas.
14. Acreage of the parcel.

Source: Menard, Stephen. Central Massachusetts Regional Planning Committee.

6.0. Map Standards and Accuracy

In order for maps to be useful they must correctly represent real world entities both geometrically and geographically to some measurable degree. Local officials producing maps as public documents have a responsibility to adhere to good standards of map production. This responsibility applies to all types of spatial data both analog and digital. Standards provide rational for how spatial data may be used by defining to what degree the data represent the real world, or in this case how accurately they depict property boundaries. Conversion processes that do not adhere to the standards discussed in this section may present difficulties for use in combination with other spatial data for analysis and evaluation. The value of a GIS enterprise is greatly diminished when parcel coverages are expected to play an important role in planning, engineering, or environmental analysis, but cannot be combined with other coverages due to mismatches in projection, scale, or the accuracy of production. When produced at a different scale or using different standards of accuracy, a parcel coverage may appear grossly distorted in relation to roads, streams, and other spatial data that reference the same geographic area.

6.1. Definitions

Spatial data standards refer to the set of guidelines or specifications that define the structure and uses of spatially related information, including hardcopy maps and digital datasets. There are specific standards that refer to the production of both hardcopy tax maps and digital datasets. This chapter does not attempt to reproduce all of the specifications involved with tax mapping, but rather to discuss those standards that are most relevant to automated parcel maps.

Spatial data standards have been promulgated regarding the content, preparation, and accuracy of maps. Accuracy pertains to the quality of data and the number of errors in the dataset. It is the degree to which information in the dataset matches true or accepted values (Struck 1999, 1). Of particular importance to digital datasets are positional and attribute accuracy. For example, entities when measured on a map at the scale of 1":200" should not vary from their real world positions by more than six feet horizontally. Accuracy is not be confused with precision, which refers to the level of measurement used to compile the data (Floode and Huebner 1995, 2). Precision takes into account how well geographic or attribute data is recorded. For instance, engineers may measure a road with great precision to a fraction of an inch. High precision does not indicate high levels of accuracy nor does high accuracy imply high levels of precision (Floode and Huebner 1995, 2)

The Commonwealth of Massachusetts Department of Revenue, Division of Local Services' (DLS) publishes a *Guideline For Tax Mapping* which addresses these issues. To obtain a copy, contact the DLS at 51 Sleeper Street, Boston, MA 02205-9490, (617) 626-2300, http://www.state.ma.us/dls.

6.2. The Importance of Accuracy

There are several facets to the issue of accuracy. First, users must consider the quality of data used to produce the spatial dataset. The conversion of existing records, without careful review of the accuracy of that information, may mean that the quality of the GIS parcel data is poor, out-of-date, or incomplete (Wright 1997). As the saying goes, "garbage in, garbage out." If the condition of hardcopy makes the transfer of accurate information into digital format highly questionable, users may wish to base the conversion on deeds or record plans held at the county or district Registry of Deeds. Of course this process does not mean that all adjoining parcels will fit together like a jigsaw puzzle. Cartographic expertise may be required to reconcile adjoining parcel boundaries that overlap or show gap.

Second, users must consider the utility of parcel spatial data. What tasks will be performed using the parcel dataset? Will it overlay with other coverages at the same scale for analysis or modeling? The GIS should not only make analysis easier, but it should also increase confidence in the outcomes of analyses. When combining datasets in an application, the outcome may be considered only as accurate as the least accurate dataset. For example, an accounting of properties with contaminated wells is accurate to the degree at which the coverages used were produced at the same scale, using the same standards for positional accuracy.

> "Contaminated well locations, plotted as points from coordinates accurate to within two feet, loose a portion of their value if property boundaries are only accurate to within +/- 30 feet." (Struck 1998, np)

Also, it is highly probable that a parcel coverage will be used to create new coverages such as zoning or landuse. Users should note that spatial datasets created in this fashion will inherit the accuracy of the propagating coverage and any errors contained therein.

Finally, the public tends to accept information presented in a GIS as fact, without questioning the data or the rational behind its application. This perception is based on the fact that maps have an inherent “truthfulness” and the accuracy of information generated by computers often accepted without question. Therefore, doubts raised over the dimensions or location of parcel boundaries depicted in the coverage must be answered with review of the property deed or a preliminary survey, not by a computation of the GIS. Local officials should be aware that parcel maps in hardcopy or digital form, are a representation of parcel boundaries and not a legal determination of dimensions or ownership (Colleary 1999). Under Commonwealth law, only a legal conveyance such as a deed or record plan provides a complete and accurate description of parcel boundaries in metes and bounds (Davis 1956, 194-195; Burgess 1999 np).

6.3. Spatial Data Standards

6.3.1. Positional Accuracy

Positional accuracy is a measurement of how close map features are to their true position on the Earth (Struck 1999, 1). The Commonwealth of Massachusetts requires that all tax maps meet National Map Accuracy Standards (Massachusetts 1987, 14). The standards were first promulgated by United States Bureau of the Budget in 1947, and require that ninety percent (90%) of all measurable points fall within $1/30^{th}$ of an inch from their true coordinate position for maps at scales larger than one inch equals twenty thousand inches (1":20,000") (US 1947). According to this standard, the horizontal positional accuracy of parcels maps at a scale of one inch equals twelve hundred inches (1":1,200") or one inch equals one hundred feet (1":100'), is +/- 3 feet (United States 1947).

As stated previously, the accuracy required of a parcel dataset is a function of its intended application. If parcel map automation is based on the conversion of hardcopy tax maps to digital format, the positional accuracy is derived from the original map.

There should be no loss in accuracy from a conversion process. Consequently, if parcel data is rectified to digital orthophotos, the positional accuracy will reflect the accuracy of the orthophotos.

It should be noted that the positional accuracy of a spatial dataset does not change as the scale of a map feature is increased or decreased visually within a GIS application like ArcView or Mapinfo.

For more information on National Map Standards see the United States Geologic Survey (USGS) web site http://mapping.usgs.gov/standards/

6.3.2. Attribute Data: Cadastral Content Standards

The Federal Geographic Data Committee (FGDC) defines cadastral data as, the geographic extent of the past, current, and future rights and interests in real property including the spatial information necessary to describe that geographic extent" (1996, 3). Cadastral maps or tax maps describe and record land ownership, or rights and interests. The FGDC's Cadastral Content Standard forms the basis for automating the parcel boundaries found in public records. It standardizes domains or the entries for feature attribute tables (FAT) and provides the definitions of all possible cadastres. The FGDC's specifications for automating parcel records depend in part on the information contained in the conveyance. Other rules are based on data integrity. One type of integrity is that all information must be referenced to a source document. Another relates to the relationship between geographic entities and attributes (FGDC 1996, 4). For instance, there should be a one-to-one relationship between the entity and the corresponding record or attributes within the FAT. This one to one relationship must extend to records of databases linked or joined to the FAT.

The Cadastral Data Content Standard is intended to support the automation of parcel records and is intended to be usable by all levels of government and the private sector (FGDC 1996, 4). The document is highly detailed and should be reviewed by a GIS enterprise undertaking the automation project. The *Cadastral Content Standard for the National Spatial Data Infrastructure* is available from the Federal Geographic Data Committee website http://www.fgdc.gov/standards/documents/standards/cadastral/.

6.3.3. Projection

To assure that other users can evaluate the accuracy and use the parcel coverage with other spatial data, it must be projected in Massachusetts State Plane Coordinates. The state coordinate system is based on the Lambert Conical projection, datum NAD83 (horizontal position), and is measured in meters.

6.3.4. Scale

Since no amount of accuracy should be lost during the conversion process, an attempt should be made to maintain the scale at which hardcopy maps were produced. Several sources specify the following divisions of scale based on the relative size and density of parcels in rural as opposed to urban areas.

Rural areas	one inch equals two hundred feet	(1:200)
Semi rural areas	one inch equals one hundred feet	(1:100)
Urban areas	one inch equals fifty feet	(1:50)

Source: Massachusetts 1982, 15; IAAO 1988, 7

6.3.5. Dimension and Acreage

If positional accuracy proves reliable, dimensional accuracy may is assumed to be similarly reliable. Since dimensional accuracy also encompasses parcel acreage, it is advisable to select a number of samples and compare acreage to hardcopy maps or the metes and bounds description found in the deed or record plan (Struck 1998, np).

When developing the FAT, users should take into account guidelines for calculating and recording parcel dimensions promulgated by the Commonwealth Department of Revenue, Division of Local Services (DLS). According to the DLS, dimensions of property lines and acreage for parcels of one (1) acre or more shall be shown on official 24" x 36' tax maps. Where no dimensions exist, a scaled dimension may be show followed by a letter "s" to indicate scaling. Where deed dimensions do not agree with the amount of distance in the spatial dataset or base manuscripts, the discrepancy should be noted with a letter "d" following the dimension. This means that the FAT should contain fields to identify scaled and discrepancy parcels. Even when "best fit" practices are used, this information will help to qualify the dataset.

6.3.6 Completeness

Completeness is a key element in assuring the creation of a quality dataset. At the most basic level, the issue of completeness refers to data omissions. For example, is there a “significant percentage” of polygons omitted from a “threshold”, or prescribed, area? On a broader scale, it is a measure related to selection criteria, generalization, definitions used, and relevant mapping rules that are used to define the dataset (Completeness 99). This defines two schools of thought: 1) quantitative completeness, or the inclusion of an “appropriate” amount of data, and 2) qualitative completeness, the adherence of data to the database design.

From a quantitative perspective, completeness is an assessment of the dataset’s existing features against what should currently be located within the dataset. “Completeness may relate to a number of digital map features: annotation symbols, textual annotation, linework. Completeness will also relate to the attribute data, and whether all necessary attributes are accounted for.” (GIS 1999). When outsourcing data conversion, a typical minimum data omission standard is 1%. For instance, if there are 250 roads in a geographical area and 2 are missing, then the dataset falls within the 1% minimum of required features that can be missing. If, however, only 225 roads (or 90%) are included, then the map is only 90% complete.

Qualitatively, completeness involves the structure of data and how it connects to the lay out of the database. In order for a dataset to be complete in this sense, it must correspond to recognized standards for precision, table structure, topology, projection and other specific requirements of the data model. All well-designed standards for quality assurance include completeness as an important component (Categories 99).

6.3.7. Parcel Identification Numbers

The parcel identification system should be easy to understand and flexible. In terms of a GIS, identifiers must be suitable links to other attribute databases and must be capable of being sorted into a logical sequential order and queried. Three examples of parcel identification systems are discussed in this chapter.

In the *Guideline for Tax Mapping*, the DLS suggest two standards for numbering parcels that may be used within the feature attribute table as the primary key for identifying the digital (1982, *17)*. The first standard uses map, block, and lot numbers. The block and lot numbers are two digits each. When parcels are subdivided, each new parcel is assigned a sequential suffix or three-digit number to the right of the decimal point of the lot number. The second standard uses the geographic coordinate locator number as the unique identifier. Coordinate identifiers provide superior information about the parcel's geographic location. The identifier is the easting (x) and northing (y) coordinate from the Massachusetts State Plane Coordinate System recorded to the nearest ten feet of the parcel's center point. The center point or tax parcel centroid may be derived through an operation of the GIS.

A third option is to use street addresses as a primary or secondary identifier. Urban and Regional Information Systems Association and the International Association of Assessors have developed a standard for parcel addressing as street address data are used as a common geographic key at the local level (IAAO and URISA 1992, 57). The organizations recommend the following format:

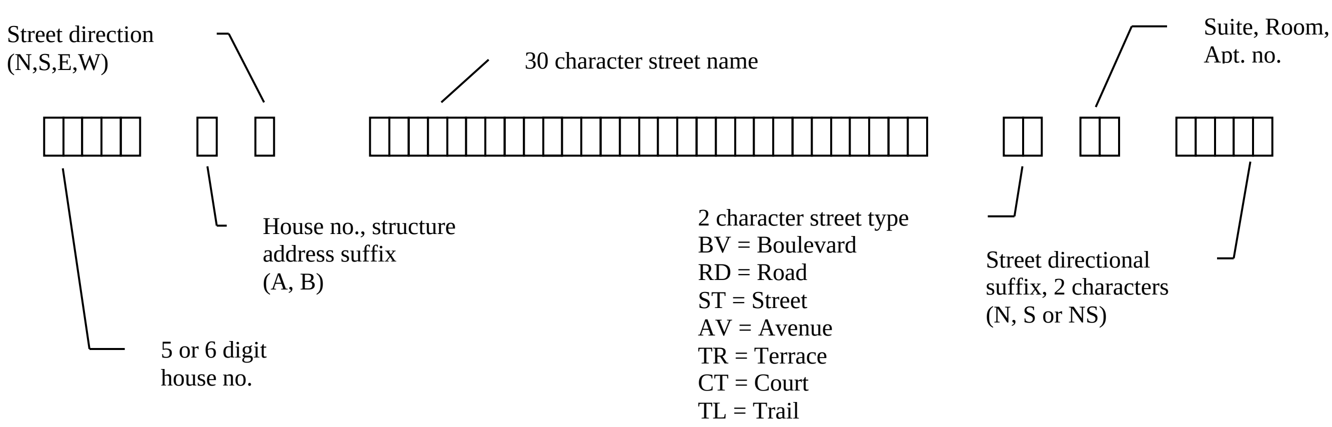


Figure 6.1: Standardized Address Format
Source: IAAO and URISA 1992, 58

To minimize redundancy and maximize the use of the spatial dataset, street names, whether they appear on the map or not, should be spelled only one way. Regardless of whether an address is used as the primary identifier, it is recommended that governments adopt this standard for use by all departments.

6.3.8. Annotation

At a minimum annotation appearing on a parcel map produced by a GIS should include the title, date of parcel conversion, date of revision(s), parcel identification numbers, legend, north arrow, scale, street names, and date of printing. Lettering and line work should remain consistent and uniform for all parcel maps produced by the GIS. (IAAO and URISA 1992, 57)

6.4. Unresolved Parcels and Errata List

Instances of parcel boundaries that do not conform to the space allotted are considered *unresolved parcels*. It is common to establish an errata list of unresolved parcels detailing their location and along with documentation as to why a parcel made the list. An errata list should be included with the documentation regarding the conversion process and construction of the coverage (see Section 8.0. Metadata).

The method of resolution is dependent upon the level of accuracy desired. Municipalities may choose to "best fit" unresolved boundaries or conduct deed research perform field checks, or conduct new surveys to create a dataset that is accurate to their needs. Users may also choose to leave discrepancies until surveys or GPS produce new findings (Struck 1998, np). The methodology for handling unresolved parcels should remain consistent. It is also important to determine how frequently unresolved boundaries occurred during the automation process. The ratio unresolved to the total number of parcels is a helpful indicator of the accuracy of the dataset, especially those produced through COGO (Struck 1999, 2). The industry standard is that the number of unresolved parcels should not exceed three percent of the total number of parcels automated.

6.5. Parcel Inventory

In the *Guide To Contracting For Tax Mapping Services*, the DLS recommends an inventory of all parcels for the creation of tax maps (1987, 13). A thorough inventory will require a measurable amount of staff time and may significantly increase the cost of automation. The precision to which this task is done will be a measure of accuracy goals for the dataset. For parcel data automation, this is the most accurate method. An inventory may include the following:

- Compiling a permanent copy of the most recent conveyance (property deed) for every parcel appearing on tax maps;
- Determining the boundaries and dimensions of each parcel using the most recent conveyance;
- If a conveyance does not exist, using surveys, aerial photographs, or contacting the property owner to determine boundaries;
- Resolving discrepancies between adjoining parcel boundaries using surveys, aerial photographs, or by contacting the property owner; and
- An errata list.

There are several benefits to conducting an inventory. First it provides the GIS development team the option to produce the dataset using COGO (see Section 2.3.

COGO). Because each conveyance is defined in terms of geometric distances and angles from control points, these data can be input into a COGO application to construct each parcel. COGO is considered the most accurate method of parcel automation. Second, if some other digital parcel automation method is used, the inventory can be used to resolve discrepancies between adjoining parcels boundaries with greater certainty. Third, an inventory that is maintained as the dataset evolves establishes a readily accessible legal record to address questions or concerns by land owners regarding the depiction of parcel boundaries within the GIS.

7.0. Check Plots

There are several sources of error that can produce inaccuracy in the spatial data. As stated early, inaccuracies within and the physical condition of the source data are obvious contributors. Errors may also occur throughout the automation process in the conversion of scales, projection into a new coordinate system, orthophoto rectification, and by human error. Whether or not the automation occurs in-house or is outsourced, check plots are necessary to confirm the accuracy and completeness of the process.

One check plot per map sheet should be prepared for review by a team well acquainted with the municipality's parcel system. Check plots may be produced on high quality paper or Mylar at a scale of 1:100. If there is strong confidence in the accuracy of the source maps, the team may also wish to produce plots at a scale that will overlay the source maps. Grid ticks indicating state plane coordinates should be displayed in each corner of individual maps. The review team should check to see if

- boundaries match the original source maps;
- all parcels are accounted for;
- right-of-ways are consistent and parallel; and
- parcel identification numbers are present along with other annotation that was specified for the project.

The team should record any gaps, slivers, or parcels with boundary dimensions that do not match adjoining parcels for correction. A second check plot may be required if extensive corrections are necessary. Any parcel that cannot be located or its boundaries determined through deed research should be recorded on an errata list and included in the metadata (see Section 8.0. Metadata).

Parcel mapping that is highly accurate in all other respects is almost worthless if queries of the attribute data continually return the wrong values (Struck 1998, np). Therefore a review of the link between the geographic data and the tax assessors' database (attribute data) should be performed as part of the check plot procedure. Specially, the team should identify:

- parcels without a match to the database;
- database records without a matching graphic parcel; and
- records referencing more than one parcel graphic.

There should be a one-to-one relationship between the parcel identification number for each digital parcel and the corresponding record within the assessors' database. Well constructed database queries and a random sampling of parcels by their unique identifier are acceptable methods to test for attribute accuracy.

8.0. Metadata

Metadata is documentation about the digital dataset. This information is valuable to users of spatial data within and outside of the municipality. Long after the dataset is created, questions may arise about the automation methodology. A document that details the automation process is useful in answering questions and helps users maintain consistency and integrity of the dataset when updates are performed. Users outside of the municipal government will rely on metadata to determine how the dataset may be used and its level of accuracy. Metadata should include, but is not limited to the following:

- reference information to organization and individual(s) who created the dataset and contact information;
- file name and format;
- date compiled;
- coordinate system;
- automation methods (scanning, digitizing, deed research)
- if rectified by digital orthophotos, the file names, dates, and location of these files;
- source documents (where housed, quantity, paper or mylar, scale);
- notes concerning errata, their location, and how unresolved parcels were handled;
- positional accuracy;
- attribute file name and format;
- attribute fields and their parameters;
- dates revised (and by whom); and
- tiling structure

Source: New York 1996, np

The Federal Geographic Data Committee (FGDC) has issued standards for the content and structure of metadata. A copy of the Content Standard for Digital Geospatial Metadata is available from the FGDC at *http://www.fgdc.gov/metadata/constan.html*.

9.0. GIS/CAMA Integration and Implementation

"One of the most effective ways to enhance the benefits of a GIS parcel base is to incorporate [data bases], such as tax assessment data, which are readily available at the municipal or county levels. While the proximity relationships of pure graphical features support a variety of GIS applications, the uses of a GIS enterprise are greatly enhanced by supporting graphical features with [this type of] attribute data." (Rehmann 1999, 1).

Assessment databases and the information they hold are fundamental to the effective operation of many government tasks. A GIS linked with a Computer Assisted Mass Appraisal (CAMA) system provides an effective tool for identifying properties and for analyzing location factors, improvement characteristics and the data that commonly affect property values (IAAO & URISA 1992). A GIS/CAMA link provides a promising framework for thematic information (i.e., house prices, average household income, and property rate) which can be superimposed on a geographic support, provided a link exists between the information and the support. "This allows for spatial cross-analyses of various urban dimensions, which adds substantially to the already great potential of straightforward statistical tools (Rosiers 1992, 30).

Offices other than the Assessor's often use the same data for different purposes. For example, while the tax assessor may use the tax assessment information as an index or to distinguish disparities in the mapping, the planner may only want to use it to assess best land use practices while taking into account environmental constraints and zoning regulations. Each of these uses is valid and requires unique data development. Reasons for unique data development and why this information should be attached to digital parcel features are often understood by individuals directly connected to the application, but may be unclear to others. In order to account for the varied intentions of all users, it is important to consider the entire GIS enterprise (the collective group of GIS users within an organization (Rehmann 1999, 1) before proceeding with any database development.

This chapter will discuss the basics of CAMA and GIS systems, and how tax assessment records can be connected with attribute parcel mapping. Relating other types of attribute data will also be incorporated because there are distinct similarities in the processes of connecting various types of attribute data to a GIS. To some degree, the tax assessment relation can serve as a blanket example.

9.1. Looking for Answers

There are no short cuts to successful integration of GIS and CAMA. There is no one blanket prescription that can detail what all Massachusetts communities should do to arrange a GIS/CAMA collaboration. Basically, there are too many site-specific variables; too many issues existing to make things simple. There are, however, commonalties within GIS and within the CAMA systems. These include the use of common databases and data structures, operating systems, scripting languages, and networks. The key is for local officials and assessors to understand their technology and environment (such as available software and hardware, cost, stakeholders, network, predicted applications and integration with the GIS enterprise) and look for other communities who have similar issues and who have had success with their integration.

Seeking out the big picture is a great way to begin. For members of the GIS enterprise not of the assessor's office, this task demands comprehension of CAMA and GIS basics. For the assessor, it involves understanding existing and available software and hardware, and the typical structure of assessment databases and their relationship to a GIS.

Assessors need “an efficient way to relate tabular data (such as that from CAMA systems) to maps of the properties that the data represent” (IAAO and URISA 1992, 8). Administratively, the ideal situation of a GIS-CAMA link allows assessors to spend less time maintaining records and collecting data and more time to evaluate information and apply skills to real problem solving. Technologically, an effective link enables a seamless integration environment and automatic data changes are reflected on either side of the link.

9.2. GIS/CAMA Integration

The State of Massachusetts defines a CAMA as “an automated system for maintaining property data, property, notifying owners, and ensuring tax equity through uniform valuations” (Guidelines 1999). CAMA is comprised of four subsystems: valuation, performance analysis, data management, and administration. When all four subsystems are properly configured, they can perform in a sufficient, user-friendly manner and interchange data freely with each of the other features.

Briefly, the significance of each subsystem is as follows:

- The valuation process involves three approaches of automated applications: income, sales comparison, and cost.

- Performance analysis incorporates the concepts of “level” (ratio of appraised to market values) and “equity” (consistency) into making sure that values can be supported and meet required standards.

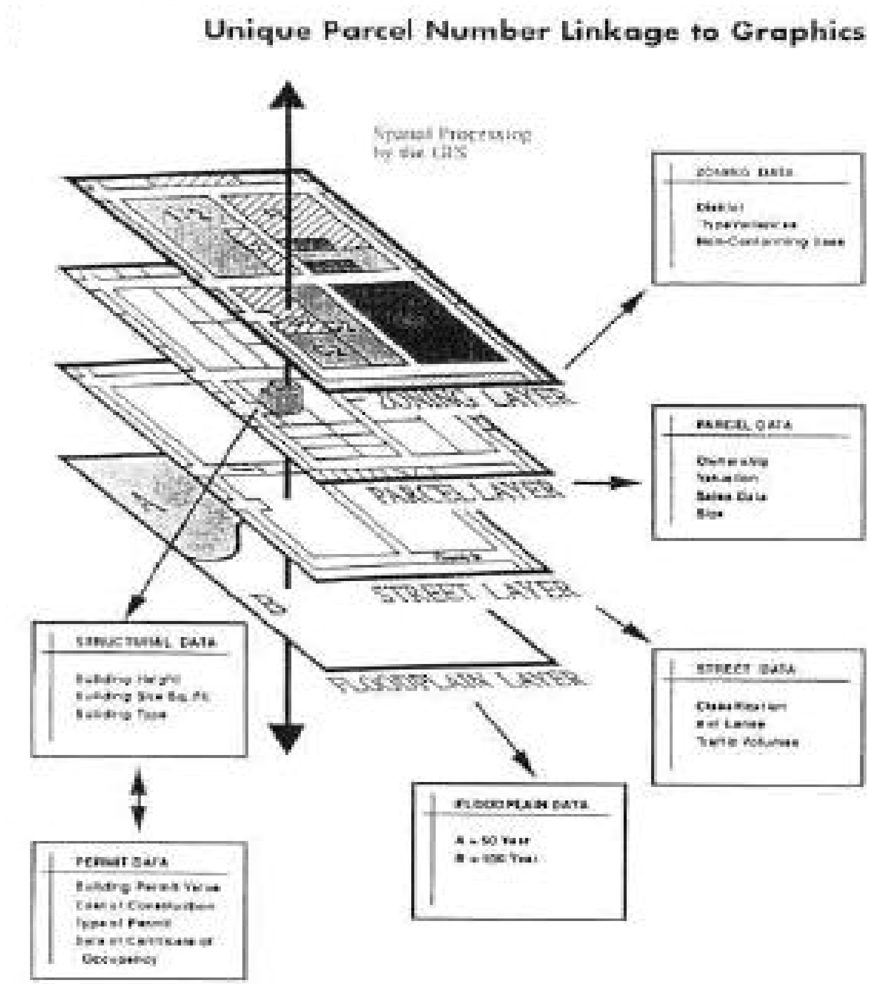
- A data management system must provide for the efficient collection, storage, maintenance and security of data.

- The administration function includes functions relating to the organization and execution of the assessment roll and various administrative activities (Guidelines 1999).

Typically, a CAMA has a structure of a relational database, one that allows descriptive information to be entered in the same database as geographic information (Hensley 1993, 23). Because extremely large data files can be cumbersome to maintain and slow to access, it is often beneficial to keep data divided into various files. In a relational database, information is typically stored and maintained in several digital files. One file may contain information about property owners such as name and mailing address. Still another might hold parcel classification information such as land use. A third may have parcel characteristic information such as number of rooms. A fourth might contain land values. "The key to a relational database is that each data file contains at least one element that serves as a link to one or more of the other files." This "linking" function is often referred to as a "relate". (Hensley 1993, 23)

A GIS, on the other hand, is "an information management tool that combines graphical features with tabular data." (Rehmann 1999, 2) Each of the graphical features has corresponding attribute data organized into a field and record structure. This table structure is commonly referred to as a "***feature attribute table***" (***FAT)***. Common FATs include the polygon, arc, and point attributes that define the individual geographic elements of a coverage. The FATs facilitate common GIS applications. For example, a user can graphically select an element or geographic feature in order to call up its corresponding FAT, or data record. FATs in and of themselves are limited in the amount of data they can provide. Thus it becomes necessary to link other attribute information to FATs. Tax assessment data is one such type of attribute information that can be linked.

In order to create a link between CAMA and GIS, it is necessary to establish a relate. Linking or joining CAMA databases to the GIS merely requires the identification of a unique attribute identifier that is common to both databases (See Figure 9.1). While the intent of each GIS application is case-specific, the method of incorporating the data is essentially the same. The goal of the process is to produce a “relationship” between the parcel features and the line items in the tax assessment data. (Rehmann 1999, 3) This unique identifier field is useful not only to match two databases, but also to evaluate the success of the matching process. It is important to realize that in most relational databases several files can be related to the selected file, but only one file can serve as the selected file. Additionally, linking other types of attribute data requires the same “relate” procedure.



(Donahue 1994, 243)

Figure 9.1: Unique parcel number linkage to graphics

Assessment databases can contain upwards of 100 data elements. Examples of these elements include the tax I.D. number, the year of assessment and the street address. The tax I.D. number is a unique number assigned to each parcel of land. There are two common identifier options in linking tax assessment data to parcel data. These include: (1) the previously mentioned tax identification number, and (2) a newly constructed character field that combines the numbers of the parcel block and the lot number or the State Plane Coordinates of the parcel's centroid (See Section 7.3.5. Parcel I.D. Numbers).

The intended use of the data and the availability of existing data often determine which method is chosen. Typically, block and lot information are used and understood widely throughout a municipality. This familiarity in addition to common usage in the digital mapping process of the parcels, may make choosing this method the best option. In the end, it is best to choose that which is most efficient and useful for each municipality.

Let's assume that the tax I.D. number field will serve as the unique identifier. In relational database terms, the tax I.D. number in FAT is called the "primary key," and the tax I.D. number in the CAMA datafile is the "foreign key." The primary key and the foreign key *must* be defined the same in both the FAT and the related table. They must also be of the same parameters such as character, numeric, integer, floating point, etc. and the same field width. If the keys are numeric or floating point, they must have the same number of positions to the right of the decimal point. It is often useful to sort the related table on the foreign key in ascending order. (Hensley 1993, 24)

9.3. GIS/CAMA Integration: Crucial Features

9.3.1. Crucial Features of the CAMA System

There are general features of a CAMA system which are important to have for successful integration with GIS. The following section outlines the suggestions of several different entities of both the public and private sectors. The following list is derived from a mixed public/private sector group who used a GIS-CAMA link to develop market models. Their work demonstrated how GIS properly linked with CAMA systems could contribute to accurate determinations of property values.

- The CAMA system must be capable of creating new data fields or adapting "open" fields for use by incoming data from the GIS. These data elements could be used in later modeling efforts.
- The CAMA system must be able to produce an ASCII file from data stored in its files. Given the specifications of this ASCII file, this capability will require special programming by the system developer.
- In order to store incoming data rapidly in the appropriate records, the CAMA system must be able to create and use an index built on parcel identifiers. The user must have built such an index before data are imported.

Source: Curry 1990.

A binary search procedure can be used to do this. In a binary search the first and last records of the related file are compared to the value of the primary key. If there is not match, the program compares the value of the primary key to the middle record. If there is no match with the middle record, the program then assesses whether the value of the primary key is lower or higher than the middle record. If, for example, the value is lower, then the record halfway between the first and middle records is found and the comparison is performed again. Bisection continues until, either a match is made between the primary and foreign keys, or the table is exhausted. Once a record has been processed the system goes on to the next record and the search begins again, until all records in the polygon attribute table are processed (Hensley 1993, 25).

9.3.2. Crucial Features of the GIS System

This list is also derived from the Curry study. It details items that are important for the GIS system's role in integration.

- Either the GIS must have a user programming language enabling users to access an incoming ASCII file and attach data from it to specific polygons, or it must have a module expressly designed to read such a file (with key parameters set by users) and place the data appropriately.
- The GIS must be able to associate key descriptors with its polygons and, in turn, associate other data elements with those descriptors.
- The GIS must be able to create new, synthetic variables derived from its analysis, associate these with particular polygons, and then translate them into ASCII format for transmission to the CAMA system.

Source: Curry 1990.

9.3.3. Characteristics of CAMA-GIS Integration

There are three possible levels of integration: parcel number exchange, periodic data downloads, and live integration between GIS and CAMA. Within these levels, there are various technical standards that should be addressed to insure successful integration. The following list is derived from the Curry project:

- **Flexibility:** A CAMA-GIS link should allow any CAMA program to exchange data with any GIS.
- **Data transfer:** Rather than one program reading the internal files of the other, data should be transferred by means of ASCII files to allow for complete flexibility in choosing the GIS/CAMA system.
- **Naming:** The ASCII transfer files should possess names that represent common naming conventions.
- **File structure:** Preferably, the ASCII files should be structured in sequential format so that they will be automatically rewritten during each use. The

CAMA and GIS programs must include information on the number, types and names of fields being transferred into the data stream.

- **Choice of data elements**

No assumptions should be made in the program as to what data elements (beyond the parcel ID) will be transferred, or where they will be placed. Users should be able to decide field arrangement per their needs. It should not be assumed that every data element received from one system would be used in another (Curry 1990).

The next table contains additional integration suggestions. These however were derived from a private sector corporation, The Sidwell Company. This information was presented at the 1998 Urban and Regional Information Systems Association (URISA) GIS/CAMA conference.

A Suggested Course of Action by The Sidwell Company
General and Technical suggestions:

Let's say you are implementing a GIS utilizing ARC/INFO/ARCView, MGE, Microstation or AutoCAD. You are currently implementing a CAMA system that utilizes proprietary data formats, flat file data structures, or relational databases which are separate from your GIS data. According to Brent Mainzinger, Software Development Supervisor of Sidwell, there are a few things to consider:

- Don't re-invent the wheel – research other communities that have comparable systems and have succeeded with integration.
- Realize that no one specific software vendor is best at GIS *and* CAMA.
- Work with knowns….acquire software tools that have successful track records.
- Be persistent….understand that GIS/CAMA integration takes time and patience.
- Use appropriate technologies that make integration easier….Window NT/'95, relational data structures, SQL compliance, 32-bit ODBC, TCP/IP, ethernet and speed.
- Open systems…refrain from data structures from which you yourself cannot retrieve information.
- Computer operating systems that can perform simultaneous multi-tasking, such as working with the map, GIS database and CAMA all at the same time (Windows NT

does this!).

- Computer operating systems that run on mainstream computers with interchangeable components (Windows NT also does this!).
- Databases that can incorporate information from multiple tables and present it to the user as a single entity (Relational structures do this!).
- Databases such as ODBC that can communicate with one another.
- Databases such as SQL that communicate in the same language.
- Networks such as TCP/IP that utilize a format understood by most other computers.
- Networks such as Ethernet that utilize systems most computers can use, and do so very rapidly.

In order to achieve a basic level of integration, the following **tools** are available for parcel transfer:

- A dynamic data exchange (DDE) in which instructions are sent between programs.
- Object linking and embedding (OLE) in which a function of one program can be used to access data from another program.
- Text file exchanges where programs are able to retrieve information from non-local files.

Utilizing the above-mentioned tools, a parcel transfer on ***one*** **operating system** might involve the following technology:

- GIS and appraisal software on NT/'95.
- Utilization of DDE and OLE to send function calls and parcel numbers between software programs (as long as the vendors are willing to modify their applications to allow this).

OR, a parcel transfer between ***multiple*** **operating systems** might involve the following technology:

- GIS on NT/'95.
- Appraisal software on UNIX or AS/400.
- An emulator such as Reflections with a 32-bit application, a robust scripting language, is Visual Basic-compatible, supports DDE and OLE and has a strong track record and a large user base.
- Utilization of DDE to perform the actual data transfer by screen-scraping the parcel number from CAMA and sending it to the GIS, or sending key strokes from the GIS to the CAMA to perform a parcel search.

OR, a parcel transfer utilizing **DOS appraisal software** might involve the following technology:

- GIS and appraisal software on NT/'95, with appraisal software running in a DOS window.
- GIS updates a text file with parcel number of interest.
- Appraisal software sees modification date/time stamp and knows to read the file and

find the parcel.

Figure 9.2: Suggestions from Sidwell (Source: Mainzinger 1998, 1.130)

9.4. Applications of GIS/CAMA Collaboration

The basic use of a GIS is in the appraisal process. Assessors tackling their daily tasks can utilize the GIS-CAMA link to answer the following questions:

- Where is the property in question located?
- How much acreage is there?
- What is the composition of the soil?
- In which tax district is the property in question located?
- What percentage of the property is wooded?
- How much road frontage exists?
- In which neighborhood is the property located?
- In which township is the property located?

Source: ESRI 1998, 1.103

Electronic data analysis, such as a GIS/CAMA collaboration, can be highly complex. Many potential applications have been identified to make use of this analysis. These functions are used to answer the above-mentioned questions. They include valuation models construction and model process performance analysis, graphic data analysis, and visual desktop review to perform on-the-spot inquiries.

Valuation models are used to estimate accurate property values. Use of the GIS/CAMA collaboration to construct and analyze these models is extremely useful for making more efficient and productive use of an assessor’s time.

Graphic data analyses incorporate appraisal analysis and thematic map production. Standard (base map), neighborhood, sales ratio, land-to-building ratio, value per square foot/acre, and small-scale are some of the types of thematic maps which can be produced to assist with analysis tasks, examples of which are listed in Figure 9.3.

Appraisal Analyses	
· Comparisons among properties · Redelineation of neighborhoods · Specific analyses of household infrastructure · Routing of field staff · Property search and address matching · Buffer generation · Review and display of adverse influence factors · Tracking building permits · Demographic growth patterns · Potential tax bases · Use of remote sensing in land use analysis	· Valuation changes within specific areas · Effect of changes in unit mill levies on assessed values and absence of exempt properties · Effect on assessed values of changes in property classifications · Relation of agricultural production data to incomes and crop expenses · Verification of utility properties · Verification of aggregate tax levies for each taxing unit · Generation of updated taxing districts and tax unit maps · Overlap and gap analysis · Location of appeal properties

Figure 9.3: Appraisal analyses

Desktop review previously required a fieldtrip to the site in question. With GIS/CAMA integration, the assessor can access digital, visual information at-hand to assist property owners. This function can be enhanced with the addition of the following utilities:

- Sales selection and reporting to find comparable properties
- Links to area maps, digital photos and sketches
- Links to other maps such as zoning, neighborhood, utility and soils maps
- Links to the model generator application

As an additional benefit, the ability to perform functions such as these, and to be able to do so repeatedly, can save time and money and assist in deferring expenses of the GIS/CAMA integration (Ireland 1998, 1.20).

In addition to the various applications and analyses utilizing GIS/CAMA connections, the maintenance process of the assessor's maps can also be eased and more automated. The following maintenance processes can be performed with integration into the GIS enterprise: map updates due to splits, combinations and new plat filings, lot sizing, acreage and dimension recalculations, area and frontage calculations, and dimension annotation.

9.5. Management

Management of a GIS/CAMA collaboration is not limited to the assessor's office, but extends to the entire GIS enterprise. Because one goal of enterprise GIS is openly accessible and available data, stewardship of that data from all departments using the information should be encouraged. Departments involved in general GIS enterprise management may include Fire, Police, Environmental Services, Public Works, Planning, Utilities, Buildings, Parks & Recreation, Economic Development, Licenses, Finance and Assessor. Issues these departments would need to address include: data backup and archiving, security and access, information integration, geometry integrity, business rules, usage, currency, history and ownership (Holmes 1998, 2.38).

One way in which to handle these issues is to institute a relational database management system (RDBMS). Within this system the goal is to minimize data redundancy while maintaining department control. The RDBMS manages data and enforces the "business rules" established by the GIS enterprise. Examples of these rules include detecting data discrepancies, valid data entry, correct linework and managing workflow tasking, among others. For example, the assessor's department would retain control of the CAMA data while the mapping department controls the parcel/land base graphics. With RDBMS, any attribute changes made by members of various departments (having permission or authority to make changes) could be reflected to other departments via update messages. For example, User A may be making a change to a parcel which happens to be in the same area to which User B has connected. User B would see the changes each time the connection to the database is refreshed. If User B were to make a change to the same parcel after User A, a "warning" window might pop up indicating the discrepancy, and offer a view of User A's changes.

Another tool useful for GIS/CAMA integration management is the Macro Routine. Macro routines, or case-specific programs, can be written, for example within ARC/INFO, to simplify map production. Routines written in ARC/INFO use ARC Macro Language (AML). Other programs, such as ArcView, would utilize the programming language used specifically by their software, like Avenue. Macros perform repetitive functions and operations. Extremely complex sets of commands can be executed automatically while user interaction is kept to a minimum. Macros require conditional logic. This is necessary when program variables are subject to constant change. An example is subdivision of a neighborhood contingent upon fluctuating local development over an extended period of time. Conditional logic applies, for example, to the selection of the household numbering within the neighborhood. The numbering scheme must account for the possibility of future development.

9.6. What's the Current Situation?

9.6.1. The Industry

Across the United States, there are many, many GIS sites that have not integrated their appraisal and mapping systems. Even though the mapping process is now automated, it is a very powerful tool that is significantly underutilized. Of those regions in the U.S. that have connected GIS and CAMA, there are many levels at which the integrations are functioning. One such level entails one-way connections that use file transfer processes to either, provide data for visualization of appraisal data for GIS users or, to generate data on the GIS side and use it to update the appraisal database. A small number of communities have established bi-directional integration. These communities have been able to overcome technical and organizational factors, in addition to under-developed GIS databases, to make the best use of GIS functionality. At this pinnacle of success, users are able to use GIS to create new data and eliminate redundant data entry.

What are the technical and organizational factors making it difficult for communities to effectively and efficiently integrate GIS and CAMA? (ESRI 1998, 1.110)

Technical Factors:	**Organizational Factors:**
· Different platforms for CAMA & GIS · Inadequate network connection · Inadequate database integration · Inability to modify GIS or CAMA systems · No technical expertise to perform the integration	· Mapping and appraisal functions are separate · Control of the database · Integration does not fit the current workflow

Figure 9.4 Technical and organizational factors

Fortunately, in the future these problems may be curtailed (See Section 9.8. The Future: Emerging Trends).

9.6.2. Evolution of the Assessor's Role

Previously, as of the mid-to-late 1980s, the primary role of the assessor's office was to accurately and efficiently ascertain property values. With the broad acceptance of GIS by assessors in the 1990s as a subsystem of CAMA, the role of the assessor has broadened to include that of information manager of the CAMA system for use in GIS. The role has evolved from CAMA tax account data manager, to CAMA data facilitator, to GIS data organizer. GIS should be a hub of CAMA and not merely a subsystem. Additionally, this evolution of an assessor's role should not be downplayed by communities lagging behind in the process, because the integration of GIS and CAMA is not a question of IF, but rather, WHEN and HOW (Ireland 1998, 1.18).

9.6.3. Massachusetts

The percentage of communities in Massachusetts integrating their CAMA and GIS systems is presently not known. Through interviews with various assessors' offices, and communications with attendees at the 1999 New England Urban and Regional Information Systems Association (URISA) GIS conference, it is clear, however, that a large majority are either interested in migrating towards a GIS enterprise, or are in the midst of a needs assessment or partial implementation (Scheid 1999).

There are many types of CAMA systems available. In Massachusetts, there are essentially three alternatives for municipalities: in-house development, a commercially available system, or generic software tailored by a consultant to the needs of the assessors department. In-house development is customized, yet expensive and time-consuming. Commercial systems are practical, yet create dependency upon a vendor. Adaptable generic software is highly functional, user-friendly and easily modified. A fourth alternative would be a combination of the three mentioned above such as supplementing a vendor-supplied system with generic software (See Section 10.0. Outsourcing).

To assist Massachusetts' communities with automation and CAMA acquisition, and to enable compliance with a legislated mandate for the establishment of local CAMA systems, the Department of Revenue created CAMA and Tax Administration software. This represents an example of the fourth alternative: a combination of state-developed software, commercial software, and vendor-supplied enhancements. The most current upgrade, constructed with assistance from SIGMA Corporation, uses Oracle database software as its core, can run on a stand-alone PC or a large multi-processor server, works with a variety of operating systems such as Win95, NT Server and SCO Unix with Windows clients, and uses 32 bit technology. This is in addition, but not limited to, enhancements such as user-defined fields and public access programming (Davies 1997, 1). Approximately 87 communities out of 351 in the state use the DOR software (Hyde 1999). For those communities not using the State system, the two most commonly used commercial CAMA systems include Patriot, and Vision by Vision Solutions (www.visionsolutions.com). The Patriot system is built on SQL Server and Vision is built on Microsoft Access (For further information on the Patriot system, contact the assessor for Townsend, Massachusetts.) The Town of Amherst uses Vision CAMA Software. By the end of 1998, Vision released a new version of their CAMA software that is Oracle-based and runs on Windows 95, 98 and NT. In order to link Amhert's Vision CAMA software to the GIS, the map-lot numbers within the GIS will be linked to the map-lot numbers stored in Vision's REALMAST file. With this link intact, the GIS will be able to read data from all of Vision's files such as the Land, Parcel, Building, Permits and Construction databases. The link will enable Amherst to query Vision data from within the parcel GIS and also query the parcel GIS to retrieve Vision data. Several New England communities utilize a "custom" VISION/GIS link developed by Camp, Dresser and McKee of CHAS. H. SELLS, Inc. Information on this custom link can be obtained by contacting SELLS, Inc. directly (CHAS 1998, 36).

To further assist communities, the Massachusetts DOR's Division of Local Services has established a CAMA Software Consortium (CSC). The Consortium "was formed to provide a flexible, responsive means for communities using the DOR CAMA and Tax Administration software to fund, specify, and contract for future enhancements to the system as well as to migrate to new technologies as appropriate" (Davies 1999). The goal of the State CAMA program is to increase local self-sufficiency and professionalism. While the DOR maintains the base CAMA system and continues to train assessors and collectors, the CSC is actually run by regional representatives elected to a Board of Directors. Administration and purchasing for the organization is handled by the Franklin Regional Council of Governments.

9.6.3.1. Massachusetts' Case Studies

9.6.3.1.1 Townsend, Ashby and Lunenburg

In 1997 the north-central Massachusetts towns of Ashby, Lunenburg, and Townsend, under the direction of Regional Tax Assessor Harald Scheid, sought to undertake the development of a Geographic Information System. From the beginning it was clear that selling the town fathers and citizenry on funding a GIS program required that: a) all town departments have access to the system, and b) the GIS not be a "fancy mapping system", but a powerful analytical tool enhanced by its integration with the towns tabular data resources.

This case summary highlights the development of a "Core Municipal Database" (CMD) developed for the towns of Ashby, Lunenburg, and Townsend. Many communities have acquired GIS technology and benefited from the new perspectives a spatial view of their community provides. While much planning usually precedes development of the graphical components of a GIS, communities are often at a loss about how to develop the equally important tabular database component. Ashby, Lunenburg, and Townsend have developed a comprehensive municipal database that pools data from the various departmental systems and databases.

The goals in developing a CMD are as follows:

a) to bring real estate data held by the various town departments together into a uniform, centrally accessed and maintained data reservoir without requiring departments to abandon their current computer applications;

b) to define, create, and maintain new data elements not currently stored in existing databases, and provide a depository for data currently stored in manual form;

c) to insure a uniform database standard, minimize data redundancy, and maintain data currency;

d) to allow for a dynamic database that can grow as new data needs emerge;

e) to maintain a database definitions document describing CMD tables and data elements;

f) to provide for easy integration with ESRI ArcInfo/ArcView, thereby enhancing the value of GIS; and,

g) to make data available to the public and other institutional users via the Internet.

Database Description

The common key linking CMD tables to the GIS is a 22 character "Parcel Identification Number" (PID). PID numbers follow the following format:

State - Community Number - Map Number - Lot Number - SubLot Number

example: MA299-0034-000123-0001

Four tiers of database tables make up the CMD. They are described as follows:

Primary Tables These tables make up the core data elements that can be accessed by GIS users

Tables and Descriptions (examples)

Dbmaster.dbf	location, ownership, addresses, and use
Dbbounds.dbf	political and other jurisdictions
Dbmsland.dbf	land characteristics and measures
Dbownhst.dbf	ownership history and recording info
Dbcensus.dbf	occupant profiles
Dbphotos.dbf	digital photographs
Dbresbld.dbf	residential building characteristics
Dbcondos.dbf	condominium building characteristics
Dbmultis.dbf	multi-unit residential building characteristics
Dbcombld.dbf	commercial/industrial building data
Dbstructs.dbf	other detached buildings and structures
Dbpermit.dbf	building permit data
Dbsales.dbf	complete sales record showing transaction data and primary property characteristics at time of sale

Secondary Tables These tables are generally available to all GIS users but may have limited or specific value to only one department.

Tables and Descriptions (examples)

Dbinspct.dbf	property inspection log
Dbordcnd.dbf	land use orders and conditions
Dbasland.dbf	assessors land assessment breakdown
Dbchpmst.dbf	detail about chapter 61, 61a and 61b lands
Dbvalhst.dbf	history of tax assessments
Dbvalrec.dbf	current valuation data

Tertiary Tables Adhoc tables, usually of a temporary nature, defined by individual users

Tables and Descriptions (examples)

Dbslstmp.dbf	listing of recent sales transactions for which registry deed copies have not yet been received
Dbgrowth.dbf	table of newly constructed and improved properties qualifying for exemption from Proposition 2 _.

Lookup Tables Series of lookup tables underlying primary and secondary databases that provide for uniform data entry

Tables and Descriptions (examples)

Luusecod.dbf	Massachusetts standard property use codes
Lubstyle.dbf	building types and styles
Lustruct.dbf	table of miscellaneous detached structures
Luheattp.dbf	heating systems
Luphsdpr.dbf	types of physical depreciation/deterioration

<u>Populating the Database</u>

Once the shell CMD and documentation describing its tables and field attributes had been established, a conversion utility was developed that extracts data from departmental databases. Extracted data is reformatted and deposited in each of the CMD's tables. Once source and destination directories have been defined, the conversion utility requires little human interaction. Options are available to selectively update primary tables, or erase and rebuild individual tables. To fully convert available data takes about 3 seconds per parcel running on a Pentium 233Mhz microcomputer.

An important feature of the CMD is the use of "long labels". Most databases and computer applications use abbreviated field values that are unintelligible to the untrained user. For example, a code describing clapboard siding might in one assessment database be labeled 'FB' (meaning frame construction with board siding). In still another assessment system the same clapboard siding might be signified by a numeric code such as the digit '6'. These short labels are of no value to a user unfamiliar with the codes. The CMD uses unabbreviated, long labels. In the example above, a property with clapboard siding would carry a field value "FRAME-CLAPBOARD" in the building characteristic field for exterior construction.

Updating the CMD is performed on a monthly basis, or more frequently when departmental data has been updated. The process is usually run over-night.

Other CMD Uses

The dBase formatted tables making up the CMD can be readily queried and imported into other desktop computer applications with no further conversion necessary. MS Excel is especially adept at accepting CMD data. Mail merges utilizing current ownership data found in the CMD are easily processed.

Hopefully, the CMD data will soon be available over the Internet. The "front-end" application to manage web-data browsing is currently in the planning process. It is anticipated that most real estate professionals, investors, developers, and citizens will welcome the easy access to public records. State and regional governmental agencies will likewise have access to both GIS and CMD resources.

The Commonwealth of Massachusetts and its constituent communities may see the value in adopting a uniform database standard that does not require the abandonment of existing municipal applications. Inquiries about this project should be addressed to Harald Scheid, Regional Tax Assessor for Ashby, Lunenburg, and Townsend (PO Box 135, Lunenburg, MA 01462, (978)597-1706 (M&Th), (978)582-4145 (Tu&F), or (978) 582-2427 (W)).

9.6.3.1.2. Newton, MA

Newton's CAMA serves as the main attribute database attached to the parcel layer, containing hundreds of columns of attribute data. Their system, like most others, is responsible for storing data on parcels for creating the property tax bills for the city.

Traditionally a COBOL application, Newton uses a CAMA system written by SIGMA (not the Department of Revenue's SIGMA system) which is based on an ORACLE relational database management system (RDMS). SIGMA decided to port its CAMA application to ORACLE based on local communities' interest. Even before the SIGMA CAMA application became available, Newton agreed to purchase the ORACLE software, knowing that scripts would have to be written in the interim to take the COBOL data and load it into ORACLE. Prior to final development of the new SIGMA system, ORACLE table structures were available, so the extraction scripts were written and run on a weekly basis. They provided the Newton GIS community with fairly up-to-date, comprehensive parcel attributes such as owner, property values, structure values, last sale date, parcel details and structure details.

The ARC/INFO parcel coverages were linked via relational database interface to the ORACLE tables, which stored the CAMA data. The only attribute stored in INFO was the parcel number. Previously, the casual GIS user was offered a user interface that facilitated access and query of the CAMA database. When SIGMA's fully ORACLE CAMA system became operational, the GIS coverages were linked into the transaction database in a read-only fashion (Terner 1995, 6).

9.6.4. Software and Hardware Case Studies: Beyond Massachusetts

9.6.4.1. James City County, Virginia

Currently, all assessor's information, the CAMA database, exists in ProVAL, a windows-based software. The CAMA database is in an R-based programming language that is difficult to translate into Arc/Info and ArcView. In order to accommodate for this, the information is translated into a structured query language (SQL) platform and then put into Microsoft Access for formatting. Once formatted, the information is saved as a Dbase file format (.dbf) file and placed on the server for enterprise users. Users must copy the information from the server onto their own systems, using their own previously designated project names to maintain consistency and avoid re-linking or re-building existing projects. The county's goal is to also convert the tax billing system into SQL platform, and then use ArcView's "SQL Connect" function to create links and views for enterprise users. This system allows constant access to daily-updated data, while preventing manipulation of data. As it currently exists, users must download the data on a regular basis to account for all updating (Daniels 1999).

9.6.4.2. Johnson County, Kansas:

In the 1980s, local officials in the Kansas City metropolitan region observed rapid growth taking place and recognized the need for a reliable, dynamic and multipurpose automated mapping system. A five million-dollar GIS project was initiated in 1985 and, despite delays and poor performance from the conversion contractor, it was completed in 1992. The Automated Information/Mapping System (AIMS) that was developed contained lot lines, plat boundaries, property boundaries and unique parcel identifiers, in addition to the Public Land Survey System (PLSS) and other cadastral features.

The tax appraisal staff utilizes the system via customized map products and formats to assist with their daily procedures of identifying, listing and valuing properties. Graphic data analysis of the tax assessor’s database information is performed by associating the CAMA with AIMS, the geographic database. No “live” link exists between AIMS and CAMA. CAMA data used in the GIS must first be downloaded as ASCII data from the county’s IBM 3090 mainframe to a PC station to a UNIX station where the ARC/INFO software resides. On the workstation, the raw ASCII data are imported into a predefined INFO table. The process is slow but effective. In the future, the appraisal office would like to have a direct, interactive link between AIMS and CAMA so that all analysis will be as current as the data (Hensley 1993, 19).

9.7. The Future: Emerging Trends

The future holds much promise and sophistication for GIS and CAMA integration, in addition to continued ease of use for assessors and the GIS enterprise. The following is a list of innovations being addressed at the time of publication of this document:

- Maturing GIS databases;
- Sophisticated use of GIS;
- Pressure on vendors to integrate with GIS;
- Improved network connectivity;
- Improved database capabilities such as ODBC, or Open Database Connectivity;
- Open system linkages (bi-directional);
- Combining attribute demographics with population demographics by linking CAMA and Census data;
- Correlation of purchasing power to property attributes instead of to social and economic factors;

Source: ESRI 1998, 1.114 and Ireland 1998, 1.21.

9.8. Final Thoughts on CAMA/GIS Integration

GIS is quickly becoming an important mapping tool in many assessment jurisdictions. Properly used, a GIS can provide assessment administrators with a powerful means for analyzing information in the form of “intelligent” maps, using relational database management software to link descriptive data with graphic data. In observing the tactics of various communities for connecting their GIS and CAMA systems, it can be seen that connection methods are case-specific to the needs of each community and its local government. Some standards can be recommended, but ultimately, it is crucial to ascertain what is most important for the local GIS enterprise.

10.0. Outsourcing versus In-House Operations

The decision to contract with a vendor or outsource for the automation of parcel maps should depend upon the organization need for the dataset, abilities to produce it in-house, and the available budget. The benefits of outsourcing may include overall lower costs. The cost of parcel automation ranges from $1.20 to $5.00 per parcel for manually digitized vector data (New York 1996, 48). Even if cost were not an issue, a municipality must ask itself whether it has the staff, will, and ability to produce a dataset at the level of quality desired. If the answer is no, municipalities may issue requests for proposal (RFP) and evaluate the proposals submitted by various contractors. Some of the criteria that may be used in the selection of a parcel map conversion contractor include: the company's technical capability, experience with parcel automation, ability to communicate a technical plan of operation, personnel experience, and range of services (New York 1996, 49).

10.1. Request for Proposals

Individuals preparing an RFP should structure the document to allow contractors to propose an approach that meets the data quality and budgetary requirements of the municipality. The following outline details the parts of an RFP for parcel map data conversion: (For more detailed examples, see Appendix 1 which contains a sample RFP.)

A. Contract Information
- Instructions for labeling and preparation of proposal materials
- Number of copies
- Expiration date and time
- Bond percentage
- Contact person and address

B. Executive Summary

- Background of the organization
- Fundamental of the proposal in non-technical language
- Description of expected uses and benefits

C. Organizational Inventory
- Description current and/or future digital infrastructure
- Description current and/or future records data
- Description of parcel data end users

D. Statement of Work
- Nature of needs
- End-product specification
- Integration of the product into existing or future system
- Check plots
- Metadata
- Technical support, if necessary

E. Qualifications of Contractor
- Description
- Project summaries of similar work performed for other local governments
- References
- Resumes of staff involved
- Subcontractor information (if any)

F. Proposal Instructions
- Provide information regarding contractor's qualifications
- Describe in detail project procedures, implementation, schedules, etc.
- Explain how end users' needs will be met
- Describe strategies for integration in current or future system

G. Selection Criteria
- Format of the review and time schedule
- Firm qualifications
- Ability to meet needs of the project
- Reasonableness of cost and time estimates

H. Miscellaneous
- Waivers, disclaimers, liabilities
- Certificate of state tax compliance

Source: Struck 1998, np

As a reference for preparing an RFP and subsequent contract, municipalities may obtain the *Guide to Contracting for Tax Mapping Services* from the Commonwealth Department of Revenue, Division of Local Services, 51 Sleeper Street, Boston, MA 02205-9490, (617) 626-2300, http://www.state.ma.us/dls.

10.2. Performing the Conversion In-House

Local governments that decide they have the equipment and expertise in-house to conduct the conversion process face two options: to conduct the project incrementally over a number of years or within a short time frame (Struck 1998, np). An incremental approach is supportable if budgetary and personnel resources are limited. This allows personnel to schedule a portion of their time to work on the project and to learn new techniques as they go. The disadvantage of this is that high turnover among technicians is commonplace and this may present problems for the consistency of process and accuracy of the product. More importantly, the value of spatial data is based on its currency. The longer the process, the less the representative the final product is of reality and thus less valuable to a multitude of applications.

The other choice is to build financial resources and the expertise to complete the project within two to three years. Such an approach requires teamwork and the full support of top management. The project will be demanding and to meet accuracy goals there will be no margin for substandard work as a result of internal strife or a lack of the necessary technologies. The benefit however, is a quick return on investment from current and highly usable dataset. In-house teams should keep in mind that,

> "[the] most valuable data is not the data that required the most resources to convert. It is the data that is integral to the greatest number of applications throughout the duration of its useful life span. That life span begins the moment each element is converted, not at the end of the conversion project." (Struck 1998, np)

11.0. Legal Issues

This section provides an overview of the Commonwealth laws that may apply to the management of GIS spatial data as public documents and the legal issue pursuant to tax maps.

11.1. Tax Maps

Because the primary purpose of parcel map conversion is to provide for the efficient and beneficial management of tax maps, it is important to discuss the legal standing of tax maps. Under Commonwealth law there is no provision regarding how tax (or parcel) maps may be used in the valuation of property. Massachusetts General Laws Chapter 184, Section 33 (M.G.L. c.184 § 33) indicates that assessors may use maps to identify parcels taxed and that approximate boundaries without distances are sufficient for this purpose. M.G.L. c.58 § 1A makes reference to the fact that tax maps are an instrument of recording keeping. Under the law, the commissioner of revenue may require of assessors any information regarding the procedures used in keeping records, maintaining tax maps and determining the valuation and classification for taxation of property.

There is no doubt that tax maps are essential as an assessment tool in that they are a convenient record of size, shape, and geographical location of parcels within a municipality. However, tax maps, or digital representations thereof, are not legal conveyances of property. In Massachusetts, only property deeds, filed with the district or county Registry of Deeds, legally convey title (Colleary 1999, np). The deed, and any plans that are referenced and recorded with the deed, provides the precise location and dimensions of the property as measured in metes and bounds (Davis 1956, 194-195). It is for this reason that the feature attribute table of a parcel coverage should contain a source document reference, such as Registry of Deeds book and page number, for each property record in the database.

11.2. Public Records Law

The legal issues relevant to digital tax parcel data concern public access and protocols for disseminating GIS datasets. M.G.L. Chapter 4, Section 7(26), the Public Records Law, broadly defines public records to include all documentary materials, regardless of their physical form, that are made or received by any office of any Massachusetts government. The statutory definition of public records does not distinguish between traditional paper records and records in digital format (Galvin 1999, 7). Under this law, digital parcel datasets are considered public records and local governments are obliged to furnish copies, at the cost of reproduction, upon request.

11.3. GIS and Public Privacy Concerns

In many respects, the procedures for responding to public record requests for digital data are similar to those currently facing governments, with one exception. The heart of the matter lies with the fundamental ability of a GIS to link a specific location with an infinite number of databases. For example, the feature attribute table of parcel dataset may be joined to databases about health, income, or purchasing habits through an exact match to a street address and/or name contained with the table. A simple query of a single parcel may then provide information far beyond the details of assessed value and date of purchase. A public request for a municipality's parcel dataset, that has been permanently expanded to include information of a personal nature regarding the property-owner and/or resident, raises both ethical issues and state statues protecting personal privacy. It should be noted however, that under the law, governments are not required to create digital records in response to a request for information.

Exemption (c) of M.G.L c.4 § 7(26), the privacy exemption, specifically limits the dissemination of public records that contain:

> *personnel and medical files or information; also any other materials or data relating to a specifically named individual, the disclosure of which may constitute an unwarranted invasion of personal privacy.*

As a general rule, medical information is of a sufficiently personal nature to warrant exemption. Records that implicate intimate details of a highly personal nature, unrelated to medical records or government personnel, are exempt under the law. By extension, portions of public records containing such information are exempt from information requests unless there is a paramount concern for public safety regarding the information in question (Galvin 1999, 3-4).

Local governments using a GIS should recognize that information associated with a specific location may be privacy-sensitive. They should also acknowledge in their preparation and use of digital data the expectation of citizens that public records will not contain information unrelated to the purpose of the data collection. To comply with privacy exemption of the Public Records Law, local governments should consider the adoption of a privacy protection policy regarding the use and dissemination of GIS data. Such a policy would provide the basis for consistent and fair responses to requests for not only parcel data, but all datasets created by the government for their GIS. The policy may also include the following guidelines (Wright 1997, 24):

- construct and manage parcel datasets to include only that information which is traditionally relevant;

- collect, use, manage, and disclose GIS data in an format that maintains anonymity whenever possible; and
- educate all staff involved in the development, use, or delivery of GIS programs including parcel data about the privacy issues of GIS technology.

For more information on Massachusetts Public Records law, contact the Secretary of the Commonwealth, Public Records Division, One Ashburton Place, Rm 1719, Boston, MA 02108, (617) 727-2832, http://www.state.ma.us/sec/pre/prelaw/lawidx.htm.

11.4. Fees

Local governments should consider in what format parcel datasets will be disseminated and what fees will be assessed. According to the Secretary of the Commonwealth, local governments are obliged only to disseminate digital files in formats available to the government and notify the requestor to make the choice that best suits their needs (Galvin 1999, 8). Fees may cover the cost of the media and the staff time necessary to search for the requested records or segregate exempt information at a rate equal to the hourly wage of the lowest paid employee capable of this work (Galvin 1999, 2).

12.0. Maintenance

Every municipality has a protocol established to maintain its tax maps and the GIS should exploit this protocol to reduce demand on human resources and, most importantly, error (Rehmann 1999, 2). A simple method is to treat the update like a puzzle. The goal of puzzle protocol is to make updates on hardcopy map sheets and use the separate sheets to piece together the final seamless dataset. Protocol is based on a situation where the GIS dataset is broken up in pieces to reflect the number of map sheets. Thus if there were 100 tax map sheets, there would be 100 separate corresponding digital components. Users, however, will work with one seamless copy. For the purposes of updating, a backup dataset is made for compartmentalizing into "puzzle pieces." At a predetermined interval, the overall parcel dataset would be modified by substituting all of the updated GIS pieces for the older, out-of-date dataset (Rehmann 1999, 2).

Attribute data tends to change more rapidly than parcel boundaries. Therefore, methods should be instituted to maintain attribute records that are used routinely in conjunction with the parcel dataset. Users should have a standard protocol for disengaging and reestablishing the links between attribute databases and the spatial dataset. For a GIS enterprise of any size, this protocol may be more difficult to institute than updating parcel boundaries. The challenge is that multiple departments may be responsible for maintaining specific attribute databases without a clear understanding of the database's relevancy to the GIS.

Individual departments tend to have their own time schedules for updating information based on staffing resources and project demands. Often data entry is last on the list of priorities. While these updates may be performed independently of one another, a coordinated effort is required to make all users aware of the currency of the data. A GIS enterprise may find it necessary to create a "Date Of Last Transaction" field in its attribute databases (Rehmann 1999, 2). The data in this "Date Of Last Transaction" field could be used to delete old records or allow the GIS to distinguish between current and outdated records when performing operations.

Glossary

*****Address:** A means of referencing an object for the purposes of unique identification and location.

***ASCII:** (American Standard Code for Information Interchange) -- This is the de facto world-wide standard for the code numbers used by computers to represent all the upper and lower-case Latin letters, numbers, punctuation, etc. There are 128 standard ASCII codes, each of which can be represented by a 7 digit binary number: 0000000 through 1111111.

*****Attribute:** A trait, quality or property describing a geographical feature. A fact describing an entity in a relational data model, equivalent to the column in a relational table.

*****Attribute table:** A tabular file containing rows and columns. Attribute tables are normally associated with a class of geographic features. Each row represents a geographic feature. Each column represents one attribute of a feature, with the same column representing the same attribute in each row.

*****Automation**: Any process whereby hardcopy cadastral, planimetric, or topographic features are converted into a digital format for use within a GIS.

*****Automated Digitizing:** Conversion of a map to digital form using a method which involves little or no operator intervention during the digitizing stage, for example scanning for raster images or automatic line following for vector images.

*****Base map:** A set of topographic data displayed in map form providing a frame of reference or contextual information to the user.

CAD: see Computer Aided Design.

CAMA: see Computer Assisted Mass Appraisal.

*****Cadastral map:** A map showing the boundaries of the subdivisions of land for purposes of describing and recording ownership and taxation.

*****Centroid:** The geometric center of a polygon. Calculating the center of an irregularly shaped polygon requires the use of geometrical algorithms. In spatial information systems, the centroid is a point in a polygon to which attribute information about that specific area is linked.

*****Check plot:** A graphic output used to verify either the content or positional accuracy of digital data by direct superimposition on the graphic original used to create the digital record.

*****COGO**: A set of procedures for encoding and manipulating bearings, distances and angles of survey data into co-ordinate data. COGO is frequently a subsystem of GIS.

*****Computer Aided Design:** The design activities, including drafting and illustrating, in which information processing systems are used to carry out functions such as designing or improving a part or a product.

Computer Assisted Mass Appraisal: an automated system for maintaining property data, valuing property, notifying owners, and ensuring tax equity through uniform valuations.

*****Coordinate System:** A recognized reference system for the unique location of a point in space. A co-ordinate system is usually defined by a map projection, a spheroid of reference, a datum, one or more standard parallels, a central meridian, and possible shifts in the X and Y directions to locate X,Y positions of point, line, and area features.

*****Coverage:** A term that refers to a set of spatial data within a Geographical Information System. Also known as a layer or spatial dataset.

****Database:** A collection of information organized in such a way that a computer program can quickly select desired pieces of data; an electronic filing system.

*****Database management system:** A collection of software for organizing the information in a database. Typically a DBMS contains routines for data input, verification, storage, retrieval and combination.

*****Data capture:** The encoding of data. In the context of digital mapping this includes digitizing, direct recording by electronic survey instruments, and the encoding of text and attributes.

*****Data format:** A specification that defines the order in which data is stored or a description of the way data is held in a file or record.

*****Datum:** 1) Any point, line, or surface used as a reference for a measurement of another quantity. 2) A model of the earth used for Geodetic calculations.

DDE: see dynamic data exchange

*****Digital Data**: Data representing distinct objects or digits that stand for some phenomenon in the real world. Data represented digitally may be manipulated to produce a calculation, sort, computation, or query.

*****Digitizer:** A device for manual digitizing. It normally consists of a flat surface that documents can be attached to, and a cursor or puck that is used to locate and input map features into the computer.

***Digitizing:** A method of data capture that involves the conversion of data in analog form, such as maps and aerial photographs, into a digital form that is directly readable by a computer. This is normally achieved manually by a human operator using a digitizer, although methods of automated digitizing and semi-automated digitizing also exist. The result of digitizing is a digital map in vector form.

Dynamic Data Exchange: a form of interprocess communication where two or more programs can exchange information and commands.

***Emulator:** a software package or program which imitates the functions of a hardware device or other software, normally another computer. For example, a terminal emulator allows a user to execute programs designed for one type of terminal from another type of terminal. Terminal emulators are commonly used to interface PC's with mini- and mainframe computers.

Enterprise: literally, a business organization. In the computer industry, the term is often used to describe any large organization that utilizes computers. An intranet, for example, is a good example of an enterprise computing system.

*Ethernet:** A very common method of networking computers in a LAN. Ethernet will handle about 10,000,000 bits-per-second and can be used with almost any kind of computer.

FAT: see feature attribute table

***Feature:** A set of points, lines or polygons in a spatial database that represent a real-world entity. The terms *feature* and *object* are often used synonymously.

Feature Attribute Table: Attribute data organized into a field and record structure.

***Field:** A set of one or more alphanumeric characters comprising a unit of information.
A specific class of information within a database, for example, in a database of employees, one field may be 'employee_surname', another might be 'date_of_birth'. Synonymous with column.

Flat file: A relatively simple database system in which each database is contained in a single table.

***Foreign key:** One or more attributes that can uniquely identify a record in another table within a database. A foreign key is the primary key of another table. Foreign key-primary key relationships define a relational join.

***Geographic Information System:** A computer system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface. Typically, a Geographical Information System (or Spatial Information

System) is used for handling maps of one kind or another. These might be represented as several different layers where each layer holds data about a particular kind of feature. Each feature is linked to a position on the graphical image of a map. Layers of data are organized to be studied and to perform statistical analysis. Uses are primarily government related, town planning, local authority and public utility management, environmental, resource management, engineering, business, marketing, and distribution.

*****Georeference:** To establish the relationship between page co-ordinates on a planar map and known real-world co-ordinates.

*****GIS:** see Geographic Information System.

*****Global Positioning System:** A satellite based navigational system allowing the determination of any point on the earth's surface with a high degree of accuracy given a suitable GPS receiver. The network of satellites is owned by the US Department of Defense, and as such, the accuracy of the signal is intentionally degraded for non-US military users. The error introduced into the signal is known as selective availability. Error in the accuracy of GPS derived positions can also be introduced through the nature of local conditions.

GPS: see Global Positioning System.

*****Hardware:** All or part of the physical components of an information processing system. For example, hardware might include the monitor, printer/plotter, network, digitizing tables, scanners as well as the computers themselves.

*****Integration: t**he combining of data of different types from different sources and systems to provide new information.

*****Layer:** A usable subdivision of a dataset, generally containing objects of certain classes, for example rivers, roads or geology.

*****Line:** A set of ordered coordinates that represent the shape of geographic features too narrow to be displayed as an area at the given scale (contours, street centerlines, or streams), or linear features with no area (county boundary lines). A line is synonymous with an arc.

****Macros:** simple programs or batch files; a symbol, name, or key that represents a list of commands, actions, or keystrokes. Many programs allow you to create macros so that you can enter a single character or word to perform a whole series of actions.

NAD: see North American Datum.

*****Network:** Any time you connect 2 or more computers together so that they can share resources, you have a computer network. Connect 2 or more networks together and you have an internet; (1) An interconnected set of arcs or lines representing possible paths for the movement of resources from one location to another; (2) A group of computers that are linked, and are able to share peripherals, software and data. The Internet is probably the most well known example of a computer network; (3) A type of database structure. A network data model is based upon the idea of explicit links between related entities.

*****North American Datum:** The official reference ellipsoid used for the primary geodetic network in North America.

****Object Linking and Embedding:** a compound document *standard* developed by Microsoft Corporation. It enables you to create objects with one application and then link or embed them in a second application. Embedded objects retain their original format and links to the application that created them.

ODBC: see Open Database Connectivity

OLE: see Object Linking and Embedding

*****One-to-many relationship:** A relate in which one record in a table is related to many records in another table. This is the most common form of relate, as one-to-one and many-to-many relates are undesirable within an RDBMS.

****Open Database Connectivity:** a standard database access method developed by Microsoft Corporation. The goal of ODBC is to make it possible to access any data from any application, regardless of which database management system (DBMS) is handling the data.

*****Open system:** An information processing system that complies with the requirements of open systems interconnection (OSI) standards in communication with other such systems.

****Operating system:** the most important program that runs on a computer. Every general-purpose computer must have an operating system to run other programs. Operating systems perform basic tasks, such as recognizing input from the keyboard, sending output to the display screen, keeping track of files and directories on the disk, and controlling peripheral devices such as disk drives and printers.

*****Orthophotograph:** A modified copy of a perspective photograph of the earth's surface with distortions due to tilt and relief removed.

*****Oracle:** A relational database management system.

*****Overlay:** The process of superimposing two or more maps, through registration to a common co-ordinate system, such that the resultant maps contain the data from both maps for selected features. Although the term *overlay* can be applied to paper based maps, more often it applies to the use of digital data, nevertheless, the principal is the same.

*****Overshoot**: A topological error where a line projects beyond the true intersection with another line.

*****Parcel:** An area of land, usually with some implication for land ownership or land use.

PLSS: Public Land Survey System

*****Pixel:** 1) A contraction of the words picture element. Pixel refers to the smallest unit of information available in an image or raster map. 2) The smallest element of a display device that can be independently assigned attributes such as color and intensity.

*****Point:** A zero-dimensional abstraction of an object represented by a single X,Y coordinate. A point normally represents a geographic feature too small to be displayed as a line or area; for example, the location of a building location on a small-scale map, or the location of a service cover on a medium scale map.

*****Polygon:** A feature used to represent areas. A polygon is defined by the lines that make up its boundary and a point inside its boundary for identification. Polygons have attributes that describe the geographic feature they represent.

*****Primary key:** One or more attributes whose values uniquely identify a row in a database table. Also the constraint used to enforce that these column(s) are not nullable and are unique.

****Proprietary data formats:** privately owned and controlled. In the computer industry, *proprietary* is the opposite of *open*. A proprietary design or technique is one that is owned by a company. It also implies that the company has not divulged specifications that would allow other companies to duplicate the product.

*****Puck:** A hand-held device on a digitizing table or tablet used for picking menus or accurately digitizing graphic objects.

*****Query:** A statement expressing a set of conditions that forms the basis for the retrieval of information from a database. Queries are often written in a standardized language such as SQL.

RDBMS: see relational database management system

*****Relate:** The relating of two or more tables in a relational database on the basis of a common item or field. Rows from these tables are compared, and based upon certain specified criteria, rows may be retrieved, updated or deleted from the database. One of the most common forms of join operation is the *equijoin*, where the values in one table must match the values in another. SQL is a common language employed for performing join operations using relational databases.

*****Raster Data:** An abstraction of the real world where spatial data is expressed as a matrix of cells or pixels, with spatial position implicit in the ordering of the pixels. With the raster data model, spatial data is not continuous but divided into discrete units. This makes raster data particularly suitable for certain types of spatial operation, for example overlays or area calculations. Unlike vector data however, there are no implicit topological relationships.

Relational database: a database that allows descriptive information to be entered in the same database as geographic information.

*****Relational database management system:** A database management system with the ability to access data organized in tabular files that can be related to each other by a common field. An RDBMS has the capability to recombine the data items from different files, providing powerful tools for data usage.

*****Scanning:** A method of data capture whereby an image or map is converted into digital raster form by systematic line-by-line sampling using a scanner.

****Scripting language:** a simple programming language with which you can write scripts.

*****Seamless database:** A digital database storing, as one continuous data structure, spatial information spanning two or more disjointed map sheets.

*****Software:** programs, procedures and rules for the execution of specific tasks on a computer system.

Spatial data: Any information about the location and shape of, and relationships among, geographic features. This includes remotely sensed data, map data, and digital data. In the context of digital data, the term may refer to a coverage, theme, or layer.

SQL: see Structured Query Language

***Structured Query Language:** A specialized programming language for sending queries to databases. Most industrial-strength and many smaller database applications can be addressed using SQL. Each specific application will have its own version of SQL implementing features unique to that application, but all SQL-capable databases support a common subset of SQL.

*****Spatial Data:** Also known as spatial dataset, coverage, and layer. Data pertaining to the location of geographical entities together with their spatial dimensions.

******State Plane Coordinate System:** The plane-rectangular coordinate systems established by the United States Coast and Geodetic Survey, one for each state in the US, for use in defining positions of geodetic stations in terms of planar x and y coordinates.

Massachusetts State Plane Coordinate System is based upon the Lambert conformal conic map projection, NAD 1983.

***TCP/IP:** (Transmission Control Protocol/Internet Protocol) this is the suite of protocols that defines the Internet. Originally designed for the UNIX operating system, TCP/IP software is now available for every major kind of computer operating system. To be truly on the Internet, your computer must have TCP/IP software.

*****Thematic map:** A map depicting selected kinds of information relating to one or more specific themes. Examples are soil type, land classification, population density and rainfall maps.

*****Theme:** A user-defined perspective on a geographic dataset specified, if applicable, by a name and feature class or dataset name, attributes of interest, or data classification scheme.

*****Topology:** The relative location of geographic phenomena independent of their exact position. In digital data, topological relationships such as connectivity, adjacency and relative position are usually expressed as relationships between nodes, links and polygons. For example, the topology of a line includes its from- and to-nodes, and its left and right polygons. Topology is useful in GIS because many spatial modeling operations don't require coordinates, only topological information. For example, to find an optimal path between two points requires a list of the lines or arcs that connect to each other and the cost to traverse each line in each direction. Coordinates are only needed for drawing the path after it is calculated.

*****Undershoot:** A line feature, which is short of its true intersection with another line feature.

Unique identifier: a data item or field common to at least two databases chosen to perform a relate, link or join.

***UNIX:** A computer operating system (the basic software running on a computer, underneath things like word processors and spreadsheets). UNIX is designed to be used by many people at the same time (it is multi-user) and has TCP/IP built-in. It is the most common operating system for servers on the Internet.

*****Vector data:** An abstraction of the real world where positional data is represented in the form of coordinates. In vector data, the basic units of spatial information are points, lines and polygons. Each of these units is composed simply as a series of one or more co-ordinate points, for example, a line is a collection of related points, and a polygon is a collection of related lines.

*(http://www.matisse.net/files/glossary.html) Matisse Enzer 1999 “Glossary of Internet Terms”

**(http://webopedia.internet.com/) PC Webopaedia “The #1 online encyclopedia and search engine dedicated to computer technology”
***(http://www.geo.ed.ac.uk/agidict/alpha.html) Association for Geographic Information “GIS Dictionary”

****New York State Archives and Records Administration. "Local Government GIS Development Guides: Manager's Overview, Needs Assessment, Conceptual Design of the GIS." Albany, New York. 1996.

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Appendix I: Sample Request for Proposal (RFP)

Town of Amherst, Massachusetts
Request for Proposal for Photogrammetry and GIS Base Mapping