A NEW LOOK AT PLANIMETRICS
Using CAMA data to create building footprints
while troubleshooting your CAMA database

Abstract: CAMA databases are used by practically every government entity that collects property taxes. Most of those CAMA applications allow an appraiser to store a sketch of a house or building. That sketch is then used to calculate area for the many components that may make up a house, such as porches, garages, first floor, etc. The creation of a sketch via a graphical interface usually results in several x,y coordinate pairs being stored in the CAMA database. If those sketch coordinate values can be inflated with real-world parcel centroid coordinate values, which must come from a preexisting parcel GIS layer, the house sketch can be recreated in a GIS polygon layer. The resulting polygons will fall within the correct parcel and need only be rotated and moved to align with an aerial photo, in order to complete the process. The final product is a high quality, detailed building footprints polygon layer that can be used for many purposes including impervious surface calculations, and troubleshooting the CAMA database.

Keywords: Geographic Information Systems, GIS, Computer Assisted Mass Appraisal, CAMA, Planimetrics, Building Footprints, Impervious Surface
INTRODUCTION

Most county and city governments throughout the United States collect property taxes to support their operations and services. To assist in the process of appraising real property, to determine market value and thus taxes due, most tax assessor offices use a computer based appraising application/program and a Computer Assisted Mass Appraisal (CAMA) database. While CAMA database designs very dramatically the contents are basically the same since the final objective, determining property value, is shared by all.

To accomplish the task of appraising property, a wealth of information must be collected and entered into a CAMA database. Among the data that is usually stored about a parcel is a sketch of the residential or commercial buildings on that parcel. Historically, the sketch data has been used only by the tax assessors office and only within the CAMA application that created it. The idea of unlocking the sketch data and making it available to other departments arose from the need to calculate impervious surface on a parcel-by-parcel basis for purposes of implementing a storm water utility fee.

In order for the sketch data to be useful for GIS analysis purposes it must be enhanced in such a way that it more closely resembles the actual structure that it represents. The most obvious way to do this is to “spatially enable” the sketch so that it now can exist in a GIS data layer. Below is an illustration of the initial sketch, the database entries that are created, and the final output that is desired. Later in this writing, the process used to create the final output is explained in detail.
Illustration 1
Sketch Screen, Corresponding Database and Final Product

WinGAP Sketch Screen
On the sketch screen, the front of the house is always facing the bottom of the screen and the only significance of the coordinate pairs is their relative values not their absolute values. The Delta X and Delta Y between coordinate pairs determines the size of the house but give no information about the houses actual placement in the real world such as latitude, longitude, or a stateplane coordinate would.

WinGAP Database
Notice how the sketch includes six distinct polygons which are recorded in the database with six records. Each record includes a description such as “Base” for the main floor or “OP4” for a high quality open porch. Also with each record, a series of coordinate pairs is stored. At the bottom of the illustration you can see the coordinate pairs for the main floor which is labeled with “Base”. Notice the magnitude of the numbers is small since the center of the sketch screen is arbitrarily defined as 0,0.

The Final Product
This shows the sketch after it has been recreated with real world coordinates. The house is now in a stateplane coordinate system and the house has been rotated to align with an orthophoto. The integrity of the house has been preserved and we can tell that the house is made of many distinct components. This level of detail is impossible to derive from an orthophoto alone.
USES FOR BUILDING FOOTPRINTS
There are many uses for a GIS layer containing building footprints, including emergency services, housing density analysis, and change detection, but the one use that is fast becoming the most talked about is for purposes of determining the amount of impervious surface on a parcel. As communities across the country struggle to comply with state and federal storm water mandates, the search for ways to fund the compliance efforts has increased. One of the funding methods devised is to impose a “storm water utility fee” on property owners. The amount of the fee is based upon the amount of impervious surface on the property. However, to implement the fee in a fair manner, the county must be able to accurately calculate the amount of impervious surface on a parcel-by-parcel basis.

CREATION AND MAINTENANCE OF BUILDING FOOTPRINTS
The most commonly used method for creating a GIS layer of building footprints is to first obtain new aerial photography and then digitize the building outlines while viewing the aerial photographs in stereo/3D. Unfortunately, the process is very time consuming and costly. The process also has other inherent disadvantages when compared to the sketch conversion process described here. Some of those disadvantages are:

- Visual obstruction caused by trees and building “canyons”
- Detail about the structural components is lacking
- Building overhang (eaves) can give inflated numbers for area
- Resolution of photos limits digitizing precision

In the past, there was no way to update the building footprints layer until a new aerial photograph was taken and even then there was no intelligence to the process of finding the new structures that needed to be digitized.

With the sketch conversion method of creating building footprints, all of the disadvantages listed above are eliminated except for some issues related to data maintenance. Since each house has been visited and measured as part of the appraisal process, details about a structure are recorded and complete visibility on an aerial photograph is not necessary. Ultimately the aerial photograph only needs to have enough detail to allow the converted sketch to be aligned with the image. The image itself need not contain very much detail since it is not being relied upon to produce the footprint itself.

On the following page is an illustration that depicts some of the disadvantages described above.
Illustration 2
Creating Building Footprints (Traditional vs. Sketch Conversion)

Traditional Method
With the traditional method of creating building footprints the resulting product consist only of a building outline as shown to the left in yellow. This footprint, when compared to the converted sketch, is lacking detail.

Sketch Conversion Method
With the sketch conversion method, all of the detail in the assessor’s database is retained in the final product. This house consists of multiple polygons which in some cases overlap each other (basements). This method not only results in much more detailed information, it also allows the assessor to visually compare their sketch data to an aerial photography. This allows the assessor to spot errors in the CAMA database that would otherwise be virtually impossible to find while also allowing them to look for unreported additions that result in lost tax revenue.

Overlay Comparison
Notice how the traditional footprint (yellow) shows the house as being longer and deeper than it actually is (red). This is most likely due to the inclusion of eaves which ideally would not be included in the building footprint. Also notice that the wooden deck on the back of the house was missed in the traditional footprint, but was included in the assessor’s sketch. Since wooden decks are usually considered an impervious surface, including the deck is important from a storm water utility fee perspective.
THE SKETCH CONVERSION PROCESS

The process of converting CAMA database sketches into building footprint planimetrics could be accomplished in many different ways. The best method for you may depend on the design of your CAMA database and/or on your particular skill set. Here we will describe one method for converting one type of CAMA sketch data into building footprint planimetrics.

Our process planning began by investigating pre-existing tools that would accomplish some of the steps that were known to be required. During that process, a free ArcGIS add-on called ET GeoWizard was found. ET GeoWizard is capable of doing many different tasks, but its ability to create polygons from points is the one task that was needed in our conversion process. For ET GeoWizard to work correctly it had specific data formatting requirements that had to be met. Most of the steps in the sketch conversion process are related to reorganizing the data from its WinGAP format into a format that’s required by ET GeoWizard. Below is a summary of the conversion process followed by a more detailed description of the individual steps.

- Pack your WinGAP tables (removes records that have been marked for deletion)
- Import WinGAP tables to SQL Server (reorganize data to acceptable format for ET GeoWizard)
- Export a single reorganized table (make compatible with ET GeoWizard)
- Create a table of Parcel numbers and their real world X,Y centroid coordinates
- Join SQL Server exported table to the parcel centroid table based on Parcel#
- Add X values from two different tables together (inflate X sketch coordinates to real world coordinate values)
- Add Y values from two different tables together (inflate Y sketch coordinates to real world coordinate values)
- Convert X,Y coordinate pairs into a point layer
- Using ET GeoWizard, convert points to polygons
- Using basic ArcGIS editing tools, move and rotate the sketch into place

Pack Your WinGAP Tables
Pack is a FoxPro command that removes records that have been marked for deletion. It’s not uncommon for databases to contain records that have been marked for deletion, while the actual data continues to reside in the database. When the data is taken out of its native application all knowledge that the data has been marked for deletion is lost. To avoid creating house footprints that were not intended to be created, make sure your database only contains records that are valid.

Import WinGAP tables to SQL Server
With WinGAP data, the information required to complete the sketch conversion process and relate it to a specific parcel, is contained in 3 separate tables. Those tables were imported into SQL Server so that the data could be reorganized into a format that was compatible with ET GeoWizard.
For ET GeoWizard to work correctly the imported tables must be reorganized in such a way that each individual sketch vertex results in its own record in a table. The resulting exported table is shown in the illustration below. As a consequence of reorganizing the data into this format the record count goes up dramatically and a lot of information is duplicated. For instance, a very simple rectangular shaped house with a square front and back porch, would result in this table containing twelve records, four for each of the three separate components.

**Illustration 4**

**Exported Table of Reorganized Data**

This table shows the reorganized data which results in a large record count. In this table there are 716,332 records which are used to create 28,362 structures for an average of 25 records per structure.
Create a Table of Parcel Numbers and Their Real World X,Y Centroid Coordinates

Using an existing polygon feature class of parcels, create a table that contains the parcel number along with the X (easting) and Y (northing) coordinates of the parcel centroid. The units of the coordinates should be the same as the drawing units used in the sketch application. In WinGAP the unit of measurement is feet and the coordinates for the parcel centroids are in the Georgia West Stateplane NAD83, Feet. Since both systems (existing CAMA and existing GIS) are using the same unit of measurement, no additional steps of scaling the sketches up or down is required. The table of centroid values is shown below.

Illustration 5
Table of Parcel Centroid Coordinates

<table>
<thead>
<tr>
<th>Parcel No</th>
<th>Real X</th>
<th>Real Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>012 002</td>
<td>2488481</td>
<td>1442618</td>
</tr>
<tr>
<td>012 003</td>
<td>2490212</td>
<td>1442793</td>
</tr>
<tr>
<td>012 003A</td>
<td>2499681</td>
<td>1442447</td>
</tr>
<tr>
<td>012 003B</td>
<td>2491378</td>
<td>1441843</td>
</tr>
<tr>
<td>012 004</td>
<td>2491184</td>
<td>1440749</td>
</tr>
<tr>
<td>012 004A</td>
<td>2489466</td>
<td>1442269</td>
</tr>
<tr>
<td>012 004B</td>
<td>2489173</td>
<td>1442264</td>
</tr>
<tr>
<td>012 004C</td>
<td>2489838</td>
<td>1442065</td>
</tr>
<tr>
<td>012 005</td>
<td>2489302</td>
<td>1439779</td>
</tr>
<tr>
<td>012 005A</td>
<td>2490308</td>
<td>1439868</td>
</tr>
</tbody>
</table>

This table contains the real world coordinates of the parcel centroids. The units of the coordinates must be the same as the drawing units used in the sketch application.
Add X and Y values from two different tables together (inflate X sketch coordinates to real world coordinate values)

The first two tables shown below, each contain a parcel_no field that can be used as the key to join the tables together. After joining the tables together, each coordinate in the sketch_coords.dbf table should be inflated by adding the corresponding real world centroid coordinate for that parcel.

Illustration 6
Adding Sketch Coordinates and Real World Coordinates Together
Convert X,Y Coordinate Pairs into a Point Layer
Using ArcGIS’ Make XY Event Layer tool, convert the final_x and final_y coordinate pairs into a point feature class. This is an intermediate step that is once again meeting the needs of the ET GeoWizard. The resulting points should now fall within the correct parcel. The illustration below shows the results of this step.

Illustration 7
Use ArcGIS to Convert a Table of Coordinate Pairs into Points

These are the points that will eventually be connected to create the polygon components that make up the house. The center of the mass of points is located at the centroid of the parcel and does not yet have an easily recognized correlation with the house in the aerial photograph.

Using ET GeoWizard, Convert the Points to Polygons
Given the correct parameters, the Point to Polygon option in the ET GeoWizard, will connect the dots in the correct order and create multiple closed polygons that can be uniquely identified and classified.

Illustration 8
Use ET GeoWizard to Create Polygons from the Ordered Points

Once the points are converted into polygons, it’s possible to begin to see the correlation between the house in the aerial photograph and the house represented by the group of polygons. Since the front of the house always faced the bottom of the sketch screen in WinGAP and had lower Y coordinate values, the front of the house after conversion, always faces south (has lower northing coordinate values).
Use Basic ArcGIS Editing Tools, to Move and Rotate the Building into Place
As seen in the illustration above the front of the building that is created from the sketch will always be facing south and the center of the house will be located at the center of the parcel. Every building is likely to need some rotation and/or movement to properly align with the aerial photography. The rotation and movement can be accomplished manually with basic ArcGIS editing tools, but some thought is being put into making this portion of the conversion process a little more automated.

Illustration 9
Rotate and Move the Building into Alignment

Before rotation and movement, the front of the house is facing south and the center of the house is located at the centroid of the parcel.

After rotation and movement, which can be accomplished manually in a matter of seconds, the house properly aligns with the aerial photograph.

CAVEATS
Though the sketch conversion process has many advantages over traditional planimetric techniques, it is not a complete substitute. To begin with, sketch conversion currently addresses only one aspect of planimetrics, building and house footprints. Some CAMA databases including WinGAP contain information that may make it possible to create footprints for mobile
homes and accessory buildings. However, on properties that are tax exempt such as churches, 
schools, and other publicly owned buildings, it is likely that no sketch will have been created and 
it will therefore be impossible to use the techniques described in this paper to create those 
building footprints.

In addition to the shortcomings associated with tax exempt buildings, the CAMA conversion 
process is vulnerable to the effects of poor data entry. Some assessors do a very thorough job of 
measuring houses/buildings and entering that data into their CAMA database. The conversion of 
high quality data will result in a very useful output that will be suitable for use in many 
applications. However, if poor measurements are made, or if measurements are incorrectly 
entered into the CAMA database, the product of the conversion process will be of questionable 
value. If nothing else, the conversion process will let you visualize data in a way that was not 
possible before, making it easier to distinguish high quality CAMA data from lower quality 
CAMA data.

THE NEXT STEP
We are currently working on the process of creating footprints for mobile homes and certain 
types of accessories such as pools, sheds, detached garages, etc. We have examined data from 
several different Georgia counties and have discovered that the data entry techniques for these 
less significant structures varies more from county to county than do the techniques for entering 
houses and buildings. In some counties we are hopeful that the process will be fairly successful 
while we suspect the process will prove to be much less successful in other counties due to more 
relaxed data collection and data entry procedures.

The automated portion of the sketch conversion process can be done very quickly once the 
correct code is created to reorganize the sketch data. It is likely that all the sketches in an 
average Georgia county could be processed and converted into polygons in less than 4 hours. At 
least for now, the final step of the process, rotating and moving the house into its proper place, 
must still be done manually and in a one-by-one fashion. Though the process may take less than 
30 seconds per structure, several different ideas are currently being considered to further 
automate the process.