From Mylar to Digital Mapsheet – Converting Parcel Maps

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Submitted by:
John N. Hansen
GIS Programmer/Analyst
Jefferson County Assessor's Office
Golden, Colorado
80419-2500

Abstract: In 2002, the Jefferson County, Colorado, Assessor's Office successfully completed the conversion of its 1300 ink-on-mylar parcel maps to digitally-generated GIS mapsheets. This conversion was completed without significantly interrupting day-to-day GIS operations. New tools (menus, AMLs, etc) and procedures were introduced throughout the transition period, while leaving existing GIS tools in place. Project steps included annotation database design, annotation capture, conversion from 33 township-wide coverages to 1300 mapsheet coverages, and development of processes for mapsheet tracking, check-out/in, mapjoining/pullapart, and map generation, while ensuring maintenance of proper topology and edgematching between sheets, and the flexibility to easily change mapsheet extents.

- **Background**

Colorado statutes require that all county assessors have accurate, up-to-date parcel maps. The Jefferson County Assessor's Office (JCAO) began producing ink-on-mylar parcel maps of the entire county in the 1980's. In 1996, the county began developing a GIS parcel layer. Linework from the county's mylar parcel maps was scanned and digitized, and 33 township-level polygonal coverages in ArcInfo format were created. No annotation from the existing maps was captured digitally at that time.

By default, drafting staff from the JCAO became GIS technicians with the creation of the parcel layer. There was minimal formal training in GIS concepts, fundamentals, editing, etc. A rather complex parcel editing Graphical User Interface (GUI) running on UNIX ArcInfo was introduced, and the staff learned on the job. From 1996 until 2002, JCAO technicians updated the township-level parcel coverages (with no annotation), while simultaneously maintaining the parcel maps on mylar (including annotation). This dual system was not ideal, with many parceling-related tasks being performed twice, but it did allow the office to produce paper maps while also keeping the GIS layer current.

Management was enthusiastic about eliminating the dual system, while insisting that any new mapping product must follow the parcel mapping guidelines set forth by the State of Colorado, including the use of symbology unique to parcel maps (ovals, diamonds, circles, etc). At the same time there were other concerns to be addressed. It was slow and cumbersome to work with the township-level coverages, some of which contained over 60,000 polygons. This also tied up large areas of the county when the parcel work being done was generally conducted in isolated areas. Editing of the township-level coverages was done 'live' – there was no data checkout procedure, and system backups were not easily accessible. The tools available were difficult to learn, and the underlying code was difficult to maintain and update. Additionally, a plan to cross train deed transfer staff would mean more people (with little if any GIS experience) would be accessing the parcel layer for editing purposes.

- **Approach**

By mid-2000, the JCAO had confirmed that the best approach to eliminating the dual system was to migrate to a GIS-exclusive mapping & data maintenance system. A new system would be designed that would incorporate features of the existing system, while providing the new functionality necessary to make parcel maps. This new system would also try to deal with as many of the unresolved concerns as possible.

There were many steps necessary to complete the conversion to an all-digital system. These steps included: mapping database design; annotation capture; conversion from 33 township-wide coverages to 1300 mapsheet coverages; and development of processes for mapsheet tracking, check-out/in, mapjoining/pullapart, and map generation, while ensuring maintenance of proper topology and edgematching between sheets, and the flexibility to easily change mapsheet extents.

- **The Conversion Process**

Analysis of the maps

The first step of the conversion process was to determine what the final digitally-produced maps would look like. There were many options – from starting afresh and re-doing each map, to recreating the maps as they existed. Giving each mapsheet a similar map extent & scale (1:1200 scale quarter-section maps) would standardize the maps, make finding a particular parcel easier, and simplify the database design, mapping processes and programming. But it would more than double the number of maps to over 3300. Standardizing the scale to 1:2400 would reduce that number to 840, but would make areas with small parcels impossible to annotate or read. Trying to eliminate inset maps ('a-maps') proved impractical because those maps are drawn at a larger scale than the map they are taken from (a 1:1200 quarter-section map might have one or more areas broken-out onto an a-map, and those areas would be drawn at 1:600).

In the end, it was decided to recreate the maps just as they had been produced on mylar. This decision had both drawbacks and benefits. It added significant complexity to the database design, as well as to the maintenance processes and programming. It meant that we would have to deal with 56 map extent/map scale combinations (6 different map scales, maps that are insets of other maps, and many map extents, including subdivisions, quarter-section, multiple quarter-sections, section, multiple sections, township, multiple townships). These drawbacks were outweighed by the benefits, the biggest of which was that the redesign of individual mapsheets was minimized. Because the before and after products were essentially the same, tracking could be done mapsheet by mapsheet, as would QA/QC of the annotation capture and the ultimate move from mylar to electronic map production.

The next step was to determine exactly what we had. Starting with an existing list of mylar maptitles, a tracking spreadsheet was created. This spreadsheet became the key tracking device used throughout the project. Keeping it accurate & current was instrumental to the success of the project. Each of the 1300 mylar maps were individually inspected, and the spreadsheet was populated with the correct title, map extent & scale, annotation density, and number of inset areas. Any other information that might be helpful was also included, such as maps that could be combined onto/with another map, illogical a-map groupings, or unusual annotations. Because parceling was an ongoing process, the mylars were constantly changing (new mylars were still being produced, map extents were still being changed, etc.). This made keeping the spreadsheet current a challenge.

Mapping Database Design

The original GIS parcel database was not designed to produce paper maps. Its primary purpose was to create a countywide parcel layer to identify individual parcels and allow for querying. Parcel Identification Numbers (PINs) and line types (parcel boundaries, tie-bar lines, section & quarter-section lines, subdivision lines, etc) were carried, but there were no mapping-related attributes. Attributes were carried on the labels and arcs—other than a build/clean at the end of an edit session, there was no use of the Arc polygon topological model. Creating or changing a parcel in one of the 33 township-level coverages was a 2-step process. The arcs would be rendered and individually attributed. Then a label point would be created and attributed with the PIN. This system, in addition to driving the technicians crazy, was very inefficient, and led to many data inconsistencies.

The database was reconfigured to both simplify the parceling process and to create maps. The reconfiguration process consisted initially of adding items to the feature attribute tables (primarily the .pat & .aat) and then populating those items. Temporary AMLs were written to allow the programmer/analyst to populate & then manually update these new items, until their maintenance was transferred to the technicians.

Training was necessary to teach the technicians how to understand, populate and maintain the new items when they were introduced. While these new items were added to the technician's responsibilities, maintenance of many existing items was converted to automated attribution. The net affect was to simplify many of the parceling tasks. Instead of having to manually attribute arcs, polygon topology was now used to maintain most of the arc attributes. Automatic attribution was put in place for all of the parcel-related arc items, as well as for the line symbology used on the parcel maps. Attribution of new items was introduced township by township, following the timetable used for the annotation capture. During the transition period, when township- and mapsheet-level data was being edited, both the old and new systems were used. Once a user chose which township to edit, the GUI automatically determined which system to use.

Annotation Request For Proposals (RFP)

Lack of digital annotation was the main roadblock to the creation of digital parcel maps. After studying the alternatives, it was determined that the easiest and quickest way to complete the conversion to digital was to contract with an outside consultant to capture the annotation. An RFP was issued in December of that year. To help ensure that the annotation conversion process was successful, every aspect of the final annotation product was analyzed and specified **before** the RFP was published.

It was already determined that the digitally generated parcel maps would have the same scale, look & feel of the existing mylars. The annotation database was designed solely for the production of those maps. This was an important distinction. Because the parcel layer fills so many diverse roles in the county, it would have been easy to try to make the annotation solve many different problems as well. Designating the annotation for one specific product made designing the database a straightforward process. The primary tasks for the consultant chosen would be to create a custom textset (containing symbols unique to parcel mapping, such as ovals, circles, hexagons, tie bars, diamonds, etc.), and to digitally capture the annotation from the mylars.

The RFP specified the database design (including subclass & level definitions, and acceptable values for the annotation pseudo items), cartographic guidelines, and other limitations. It was then up to the consultant to propose a methodology to fit into that framework. Also included with the RFP were:

- bluelines of sample mylar parcel maps;
- the same maps produced from the GIS parcel database (linework only);
- a descriptive list of the various types of annotation to be created;
- labeled samples of each type of annotation requested;
- the estimated total number of discrete annotation elements to be captured.

The estimated total number of annotation elements was determined by using the annotation density information from the tracking spreadsheet. Annotation elements on selected representative maps from each density category were counted, and these counts were then multiplied by the number of maps in each density category. For Parcel Lot Numbers, estimates were based upon the number of unique parcel numbers in the entire database, plus about 10% for duplicate annotations. Because of efficiencies gained through data automation and improved arc symbology, as well as budgetary limitations, the RFP specified that approximately 680,000 annotation elements that existed on the mylar maps would not be captured.

Approximately 12 firms submitted proposals, and each was evaluated using the criteria set forth in the RFP. Three shortlisted firms were then required to complete a sample project before being considered for final selection. The sample project was to capture a specified quarter-section of annotation using their proposed methodology (and the guidelines laid out in the RFP). The annotation was to be attributed correctly, with proper annotation subclasses and layers.

Techni Graphic Systems (TGS) of Ft. Collins, Colorado was eventually chosen as our consultant. We were pleased with the products they produced. Fontographer (Macromedia) was used to create the custom textset symbols, and the mylars were scanned using WIDEimage (Contex). The balance of the project was UNIX ArcInfo native. With the scanned mylar images (registered to the parcel data) as a backdrop, almost 1,000,000 annotation elements were captured using heads-up digitizing. During the capture process, TGS technicians used an AML-based GUI, whose code was used to build the maintenance tools that are now used by JCAO staff to create and update the annotation.

To minimize interruption of the day-to-day GIS operations, a multi-phase project plan was utilized. Phase One involved scanning and registering the mylars. Phase Two was the actual annotation capture, and Phase Three involved breaking the coverages into mapsheet-level coverages. Phases Two & Three are outlined in the next section.

Annotation Capture

In Phase Two, the township-level coverages were prepared and delivered to TGS as export files. Part of the preparation was to datestamp the arc & label features with the delivery date. While TGS was capturing the annotation, the JCAO continued to update the township-level coverages as usual. However, if a feature was edited, its datestamp value was also updated. This allowed us to track those areas that were changed after the date they were delivered for annotation capture. On the final checkplots, changed areas were flagged to ensure that the annotation was still current.

TGS captured the annotation township by township, and provided initial checkplots back to the JCAO. Each plot was checked against the original mylars. The accuracy threshold was 99 percent, meaning no more than 1 percent error in missed elements, misspellings, incorrectly positioned elements, etc, would be accepted. Checkplots were color coded by annotation subclass to ensure each element was placed in the proper subclass. Each checkplot had annotation totals for that mapsheet tallied in the marginalia, along with the acceptable number of errors (the total multiplied by .01). This gave the checker an exact number with which to determine if a map was to be sent back to TGS for correction, and ensured that the accuracy standard was applied evenly across all of the mapsheets.

QA/QC of the checkplots was extremely important, as that was the only way to ensure we were getting an accurate, quality product. JCAO staff was trained on what to look for and how to mark up the checkplots. Regular meetings were held so that those checking the maps could discuss what they were finding, and to help ensure that the maps were being checked consistently. In addition to annotation totals, the checkplot legend contained error type descriptions (e.g. ‘Are all the elements READABLE?’; ‘Are all elements CLEARLY TIED to a feature?’) with checkboxes, which were checked yes or no. All of this information was regularly entered into the tracking spreadsheet, allowing us to run metrics on overall accuracy & map rejection rates, types of errors being found, etc. Below is a sample of the tracking portion of the marginalia.

Items with an "*" MUST be filled out
Date checked by JeffCo: ______________ *
Checked by: ____________________________ *

ANNOTATION (for TGS) Use a Pink Hi-Liter

CATEGORY	ELEMENTS	
A-Map References	3	
Hexagon Numbers	64	
Lot Numbers	773	
Metes & Bounds Lot Dimensions	128	
Miscellaneous	147	
Named Water Featues	0	
Parcel Lot Numbers	610	
Platted Block Numbers	96	
Road & Railroad Names	61	
Subdivision/Addition Names	48	
Tie Bars	24	
TOTAL # of ANNOTATION ELEMENTS	1954	
ACCEPTABLE # of PROBLEM ELEMENTS	20 or less	
# of PROBLEM ELEMENTS		*
Circle One:	ACCEPT SEND BACK	
Are all elements READABLE?	Y or N	*
Is the text CORRECT?	Y or N	*
Are all elements CAPTURED?	Y or N	*
Are elements PLACED correctly?	Y or N	*
Are all elements CLEARLY TIED to a feature?	Y or N	*
Are elements in the correct CATEGORY?	Y or N	*
NOTES:		

Conversion to Mapsheet Coverages

As mentioned above, working with the township-level coverages was slow and cumbersome. Loading such large coverages into memory for editing took many minutes in some cases, and saving changes was also excessively slow. Work efficiency suffered greatly and unnecessarily. There were different ideas as to how to break up the coverages to elevate these problems, including using a section-level or quarter township-level model. But either of those solutions would have added even more complexity to the design of the mapping database, and would have necessitated making changes to the existing map extents in some cases.

Phase Three began after the annotation capture was complete. Up to this point, JCAO technicians were still exclusively using the original parcel editing GUI on the township-level coverages. This phase marked the beginning of the transfer to the new mapsheet-level editing tools, and was the only time that parcel data was taken out of production for any length of time. Datestamped township-level coverages were taken out of production one or two at a time, exported, and delivered to TGS. No additional editing of those township-level coverages was allowed. TGS broke the data into individual mapsheet coverages (arcs, polygons and annotation) and prepared the final mapsheet checkplots. Once TGS completed and delivered a township, its mapsheet coverages were loaded onto the system and put back into production using the new mapsheet process tools.

- **Mapsheet Tools & Processes**

From a database administration standpoint, the township-level environment was quite simple. The 33 coverages were edited live (not checked out), each technician was responsible for a specific set of townships, and currency of the data did not affect the maps. Maps and data were not always in sync – sometimes the mylars were more current than the coverages, and vice versa. Moving to an environment with 1300 individual mapsheet coverages, which could be edited by any of the technicians, while ensuring the maintenance of proper topology & edgematching between sheets and the currency of the maps, proved to be the most challenging aspect of the project.

The original plan was for TGS to first develop the annotation-related code and begin the capture process, and then assist the JCAO programmer/analyst in concurrently developing the remaining mapsheet process tools. Concurrent development at both locations was attempted because of an urgency to maximize use of the allocated budget during the current fiscal year, and proved to be impractical for a number of reasons. Management of the capture process on the JCAO side became an almost fulltime job. The complexity of the mapsheet data model led to many programming difficulties. And differences in system architecture between sites added overhead to the development process, especially in testing and passing code back and forth. Ultimately, little useful code was completed during the capture phase.

Regardless of how the individual parcel coverages were organized, be it by township, quarter township, section, or mapsheet, it would still be necessary to regularly produce a countywide parcel layer. The countywide parcel layer is produced each weekend by appending the data from all 33 townships together into one seamless coverage. Ensuring that the individual mapsheets remain edgematched, which allows the countywide layer to be correctly created each week, is one of the most important features of the mapsheet processes.

Each user has their own working directory (currently there are 14 users who edit the parcel data). Keeping track of each mapsheet is the first step toward maintaining correct edgematching. The tracking spreadsheet created at the beginning of the project was converted into an info table that is used for this purpose.

When a mapsheet is checked out, the tracking table datestamp items for spatial editing (polygons), annotation editing, and mapsheet updating, are also reset. The GUI uses this datestamp information to determine what may be done with a mapsheet at any one time. If a mapsheet is checked out, another user may not check out the same mapsheet. Once a mapsheet is checked out, it must be edited in some way before its parcel map can be updated. And before a mapsheet can be checked in, its parcel map must be updated.

Task datestamping is useful in many ways. It ensures that each task is being completed in the proper order. For example, it ensures that if a mapsheet is edited, its parcel map is also updated before it is checked back in. It also gives a technician exact information about where they are in the process with a given mapsheet. With so many mapsheets (and a heavy workload), it is easy to forget what has or has not been done. If a mapsheet is checked out, but nothing has been done to it, a technician cannot update its parcel map or check it back in. This eliminates unnecessary map plotting and other processing, and helps to manage the office's GIS workflow more efficiently.

A Sample Mapsheet Process

Although there are many variations, the same basic process is used each time a change is made to the parcel database. The processes themselves are automated, and the GIS-related tasks are accessed from a single menu. Each completed task generates an update to the tracking table for the mapsheet(s) the task was conducted upon. We will use the example of a hypothetical parcel split to highlight each step.

Our hypothetical parcel falls within 2 adjacent quarter-sections. The property owner has sold off part of the original, and it needs to be split into 2 separate parcels. The technician doing the split determines that the parcel is shown on two adjacent quarter-section mapsheets. The first step in the GIS process is to check out the 2 affected mapsheets. To ensure that mapsheets remain edgematched, the checkout process freezes the outside boundaries (arcs) of each mapsheet so they cannot be changed in any way. The tracking table is updated with the checkout time, checkout person, and location of the checked out mapsheet.

Because the work being done does not fall completely within a single mapsheet, it is necessary to mapjoin the two adjacent quarter-section mapsheets. Any number of mapsheets can be joined together at once, and additional sheets can be added to the mapjoined coverage at any time. After mapjoining, the arcs shared by the adjacent mapsheets are no longer along the outside of the coverage, and are unfrozen. The tracking table is updated with the mapjoin information.

The next step is to edit the mapjoined coverage, and split the original into two new parcels. The new parcels must be attributed with valid PINs and the proper mapsheet codes, along with other attributes. Except for the PIN, valid attribute values for all items are chosen from picklists, which are automatically generated. Attributes of the (previously frozen) arcs separating the two quarter-section mapsheets can be updated. Each time that edits are saved, the tracking table is updated with a current datestamp.

After the polygonal edits are complete, the mapjoined sheets need to be pulled apart. The pullapart process first checks to ensure there is proper topology, and no null attributes. Then the individual mapsheets are recreated, using the mapsheet code values carried in the .pat, and their boundary arcs are refrozen. The technician is shown the results of the pullapart, in case the mapsheet codes were incorrectly attributed. Once the mapsheets have been successfully pulled apart, the tracking table is updated.

In our hypothetical parcel split, the parcel numbers on each mapsheet still need to be changed. Annotation is updated mapsheet by mapsheet. This allows the technician to see exactly how the final mapsheet will look, without having to deal with overlapping annotation elements. Mapsheet codes for the annotation are attributed automatically, or are chosen from a picklist. Each time that annotation edits are saved, the tracking table is updated with a current datestamp.

There are two more steps in the process. The first is to update the parcel maps generated from the checked out mapsheets. Both ArcInfo graphics (.gra) and HPGL2 (.pgl) files are produced. The last step is to check in the mapsheet coverages, along with the associated graphics files.

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Contact Information

John Hansen
GIS Programmer/Analyst
Jefferson County Assessor's Office
100 Jefferson County Parkway, Suite 2500
Golden, Colorado 80419-2500
303.271.8640
jnhansen@jeffco.us