Migrating a Road Register to a Modern Asset Management System
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By Frederick W McCamic, GIS Analyst; Roy Pickering, Senior GIS Analyst; and Naomi Lizama, Road Registrar.

Abstract

For years the County of San Diego maintained its Road Register in a database on a VAX minicomputer. Maps were drafted with ink on mylar. Over the past 4 years the County has migrated the database to Hansen software, which includes asset management, work-order creation and tracking features. Mapping has been migrated to ArcMap, and the Hansen and ArcMap components have been linked. Within the enterprise, data access is via Hansen, various PDF documents on shared network drives, and via an ArcIMS mapping application on the County intranet. Public access is via PDF documents on the County internet website. In the migration process completeness and accuracy have been improved. Internal and external access to data have been improved by moving to digital form.

Introduction

This paper discusses the migration of the County of San Diego Road Register from a system using a VAX minicomputer and hand drafted mylar maps, to a system using asset management and GIS software on a microcomputer network. The bulk migration was completed about three years ago, and, since then, the emphasis has been on assuring completeness and accuracy, and providing users with the information they need in an efficient and user friendly way.

The asset management software used is Hansen 7.7. and the GIS software is ESRI ArcMap 9.2. The tasks required are:

Convert VAX tables into Hansen.
Make a basemap that corresponds to Hansen (Road Register).
Develop a system to accurately map assets and attributes.
Clean map and database so they are synchronized and correct.
Update register, map, and associated data to reflect changes and additions.
Make maps and data available to users (County internal and public).

The Road Register is maintained by County of San Diego Department of Public Works for the unincorporated area. County government covers some functions for the entire county including incorporated cities, for example, restaurant inspection, weights and measures, reportable diseases and social services. For roads, however, cities generally take care of their own, and the State (Caltrans) takes care of state and federal roads. In the unincorporated area the County maintains roads they have accepted for maintenance.

The Road Register inventories roads that are maintained, certain non-maintained roads in cases where there may be a road sign that the County maintains (e.g. there are stop signs on a number of private roads where they meet a County road – to inventory the stop sign, we must inventory the private road). There are also roads in "Permanent Road Divisions" (PRDs) which are roads that are not accepted as County roads, but the County contracts with private owners for maintenance of the roads.

A brief statistical summary of the County and the road system:

Area of the county is: 4261 sq mi
Area of unincorporated: 3572 sq mi
Population of the County (2007 estimate) was approximately: 3,100,000
Population of the unincorporated area (2007 estimate) was approximately: 481,000

Miles of maintained road: 1,919
Miles of road in Road Register (includes NON-COUNTY & PRD): 1,982
Miles of all roads in the County (includes above plus city, private, etc): 15,913.

1) The old way:

For some years a VAX minicomputer was used to maintain the Road Register. Operating cost was about $250,000 per year. This was shared among Timekeeping, Human Resources, Capital Improvement, and Road Register functions. As the other functions were shifted to newer systems, the Road Register was carrying the entire cost of the VAX. With the Road Register shifted to Hansen, it now uses about 1/6 of a shared server that costs about $1,600 per month. In approximate terms, the new server costs annually about what the VAX used to cost per month.

Maps were hand drafted on mylar, and conformed to Caltrans' now replaced HPS map grid.

Staff access to information was via hard copy reports. Reports included the Road Register, the Road index, the Sign index and others.

Hard copies of thick reports and map books were prepared for the many County staff who needed them. Reports and maps were updated and printed once per year. Costs involved in producing each of the three publications have been drastically reduced. The two books outsourced to printing companies cost several thousand dollars. The cost to produce the HPS map books were internal costs but saved many hours of labor for plotting, collating, stapling and edge binding.

Figure 1: Naomi Lizama, Road Registrar, displays old paper reports and maps.

2) Mass migration.

The process of moving data from VAX tables into Hansen was facilitated by consulting services from Hansen and the County's Information Technology Contractor. About 50% of the VAX fields could be directly mapped into existing Hansen fields. The other 50% was in free text fields and had to be preprocessed to populate existing Hansen fields or custom tabs.

In the VAX, asset and attribute locations were described as a distance relative to the nearest reference point. In the migration to Hansen, locations had to be translated into a location as a cumulative distance along the entire road. This was further complicated by distances and lengths being described in the VAX as either or both of decimal fractions of miles or as feet.

During the migration process historical users of the VAX reports were adamant that they wanted to see reports in the familiar formats that they were accustomed to using. This required custom programming by the County's outsourced IT consultants (first Pennant Alliance and then Northrop Grumman). Custom reports were produced that looked exactly like the old reports from the VAX, including feature locations described relative to the nearest reference point, and distances given in either fractional miles or feet depending on context.

3) Using Hansen

Hansen is, first, an asset management system. It also provides facilities for work order creation and tracking and timesheet reporting. It also provides summary reporting on matters such as total expenditures that management needs and likes.

Assets tracked in Hansen include County roads, road segments, assets such as signs, attributes such as road surface, and road maintenance history. In the future it likely will be used for storm water facilities, County sewers, and streetlights.

Here is a brief summary of the numbers of items tracked.

Number of roads	3,932
Number of segments	9,769
Number of assets	48,848
Number of attributes	105,028
Number of intersections	8,685
Number of history records	397,157

Road related assets include:

Assets	
Asset Type	**Count**
Appurtenance	784
Bridge	163
Intersection	13,659
Sign	33,509
Signal	732
Street Light	1

Each asset type includes a number of subtypes. Since type “Appurtenance” is not self explanatory, we note that of the Appurtenances, 662 are MBGR (Metal Beam Guard Rail), and 47 are CATLGRD (Cattle Guard), as well as ten other types of appurtenance in smaller numbers. There are 1,144 types of signs.

There are 28 types of attributes, including, among others, REF PT (reference point), which generally coincides with intersections, MNT DIV (maintenance division), MNT STA (maintenance station), INV DT (inventory date), SRV DIR (survey direction), SURFACE (type of pavement surface – mostly AC or asphalt concrete), TRAV WY(travel way width), LFT C/S and RT C/S (left and right codes for curb and sidewalk), CT ID and CT FC (Caltrans ID and functional code).

Attributes	
Attribute	**Count**
01 REF PT	13,926
06 MNT DIV	4,077
11 MNT STA	4,101
12 ST DIST	4,094
13 TB	5,849
14 INV DT	5,101
16 SYSTEM	3,657
17 SRV DIR	4,123
18 SUP DST	3,863
20 SURFACE	4,111
21 TRAV WY	4,520
22 CITYMNT	2
22 RD BED	5,835
22 REF RD	1
22 SHARED	13
23 LFT C/S	4,904
24 RT C/S	4,884
25 LANES	3,683
26 JURISD	154
30 CENSUS	4,228
31 SPD LMT	22
40 CT ID	3,773
41 CT FC	3,721
50 SEQ NO	9,764
51 AAR	429
52 HPS	6,155
53 HT LMT	32
SPEED LMT2	6

Hansen provides graphic viewing of assets, and a tabular view of attributes. The screenshot below provides an example, MAINE AV.

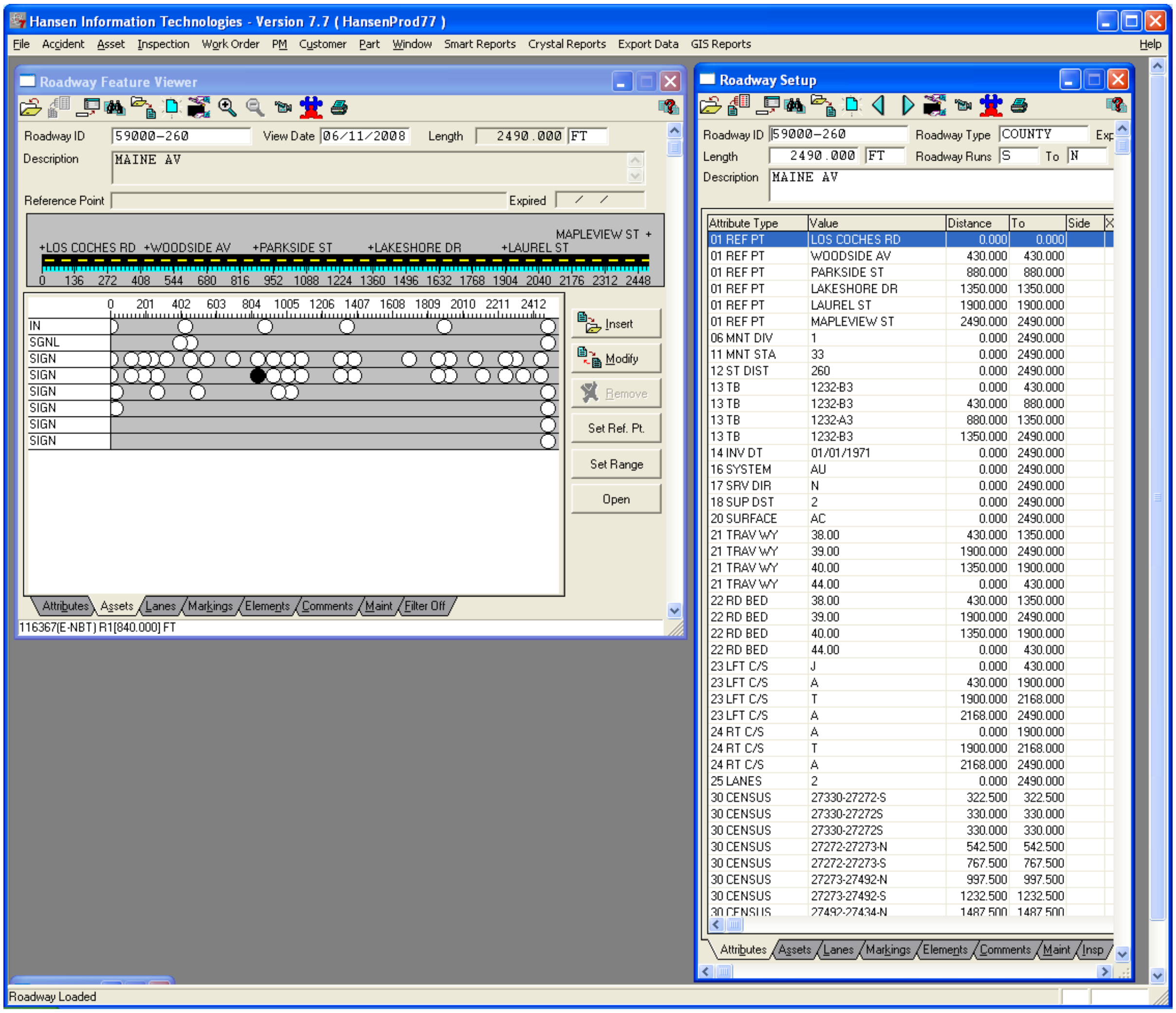

Figure 2: A Hansen screenshot showing how asset locations are displayed (left) and how attributes are listed (right). Note how attribute locations are as from-distance and to-distance. The same scheme applies to assets. Point features have from-distance and from-distance that are equal.

4) Making a map of County roads

A previous roads-mapping application (Roadview) had been developed by San Diego Data Processing Corporation (SDDPC) using Arcview 3.2. In that application, segments of road were defined by the beginning and ending intersection number and an id number generated by concatenating the two five-digit intersection numbers. A batch job running on a Unix workstation extracted road segments from the SanGIS road coverage. (SanGIS is the regional data warehouse and is a “quasi-private” joint venture funded by the City of San Diego, the County of San Diego and most of the other cities in the county.) An effort at reconciliation had improved the matching of segments between the County road shape file and the Road Register from 85% matching to 96% matching. Following the data migration from the VAX to Hansen, we considered continuing the extraction strategy, but ultimately abandoned the strategy for several reasons. We had hoped to get a maintenance flag attribute added to the SanGIS road layer, but SanGIS was unwilling to add an attribute to their table. Realignments and additions in roads that we needed to reflect quickly in our road layer took too long to be updated, and, finally, there were instances where the actual location of roads did not match the existing layer, and SanGIS was reluctant to make changes unless they were described in formal survey documents. Once we decided that the extraction approach was not viable, we took a subset of SanGIS roads and began editing a County road layer of our own.

When we began to build the new road layer, we found that the segment match rate was back down to 85% and the reconciliation began again.

The matching process has now produced a match rate of over 99%. (The goal is 100 %.)

Our quality control process includes the following steps:

1. Visually examine the GIS layer overlaid on scanned and registered copies of the old HPS mylar maps.

2. Match Hansen segments to GIS layer segments and vice versa, to detect orphan Road Register records and orphan GIS layer segments. Correct as needed.

3. Compare the Hansen Road Register length of segments to the geometric length of the GIS segment. Investigate large length differences and correct.

4. Visually compare the GIS layer to aerial photos and to GPS traces generated during a previous pavement condition survey.

5. For occasional instances we field check a road using a vehicle with a foot meter, and a GPS unit.

A number of instances were found where the mapped centerline of the road did not match the aerial photo. There was considerable debate over how to handle these instances, with one position being that the “system of record” should record the official record, and the other position being that reality was ascendant over paper. Ultimately it was determined that we pave the road not the paper, and we would map the actual location of the road.

Figure 3: Left panel shows how road on aerial photo does not match vector data. Right panel shows road centerline edited to match reality.

In some cases, there are errors in measurement of the road, e.g. between two intersections, and either the Hansen record or the GIS record needs to be corrected. There are three ways of dealing with this problem:

1) QC the mapping and length of the road. Sometimes there is a plain error that needs to be corrected in either the table or the map.

2) In some cases we may make use of the RUBBERBAND UTILITY. This is a custom program that adjusts all of the data for segments of a road from the old length to the new length. “All” of the data includes asset data, attribute data, and history records. This would be done if it is ascertained that the GIS layer is mapped correctly and the Hansen length is in error and in error by a fairly large amount.

3) Where the Hansen and GIS lengths differ by a small amount, the ROUTE built from a road will be calibrated. (Actually, all routes are calibrated. Anything not fixed completely by step 1 or 2 will be fine tuned in step 3.)

5) Using the map: Making routes

Much of the information stored in Hansen is in the form of distance along the road from the beginning. In ESRI ArcMap, dealing with this form of information is done via Linear Referencing. The next step, therefore, is to build routes. Routes are line features with a Measure. Various attributes and assets may then be represented as EVENTS.

Routes may be edited one at a time, but for us, at least for now, we are maintaining the shapefile of segments as a base map, and from time to time, we build routes afresh from the segments. The route building process uses the route building tool from the toolbox. The steps are to determine the starting quadrant for each road based on the XY of the first and last intersection. This is done via custom programming in Hansen. The resulting table is exported and joined to the maintained roads layer, which is exported to a shapefile. That shapefile then has a starting quadrant attribute with possible values of "LL", "UL", "UR" AND "LR." Those values are used to select lines and export them to four shapefiles, one for each beginning quadrant. Routes are then built in ArcToolbox using the "Create Routes" tool with the appropriate coordinate priority. Finally, the four route shapefiles are appended into a single route shapefile. This process has been incorporated into a model created with the model builder.

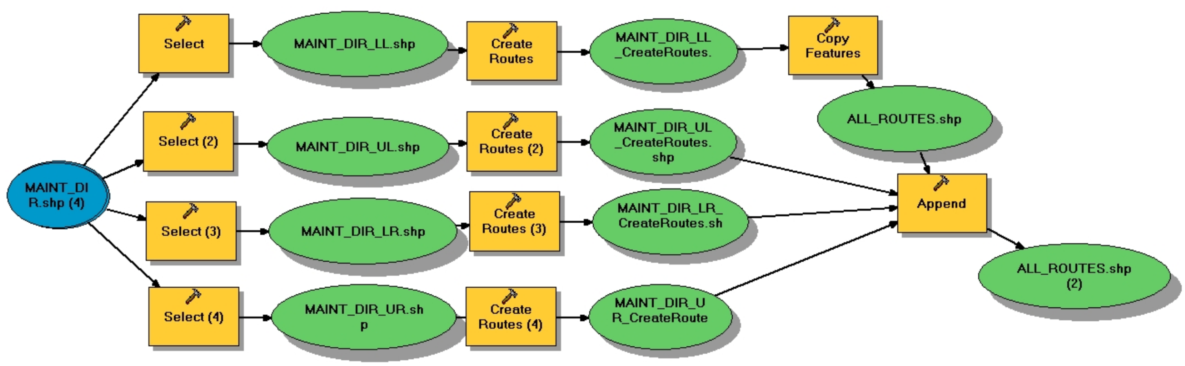

Figure 4: Model diagram showing the process of selecting roads by starting quadrant, building routes, and appending routes back together into a single route layer.

A final step is to CALIBRATE the routes so the Road Register distances for intersections are used to control the route measure. The calibration process requires the creation of a table indicating for each road, the "official" distance from the beginning of the road for each intersection. The calibration tool adjusts the route measure so it will achieve the official Road Register distance at the indicated intersection.

The illustration below shows the problem with an uncalibrated route. Both panes show a linear event from the table of the attribute 40 CT ID, the Caltrans ID, which is effectively a surrogate for County maintenance. The example road CLOVERDALE RD is measured from south to north, with the road going into and out of the City of San Diego.

Within the City, the City is responsible for maintenance; in the unincorporated area, the County is responsible for maintenance. Due to accumulated error, the tabulated distances shift the maintained events about 140 ft too far south on the uncalibrated route, shown in the left pane of the figure. In the right pane of the figure, the calibrated route yields a correct map.

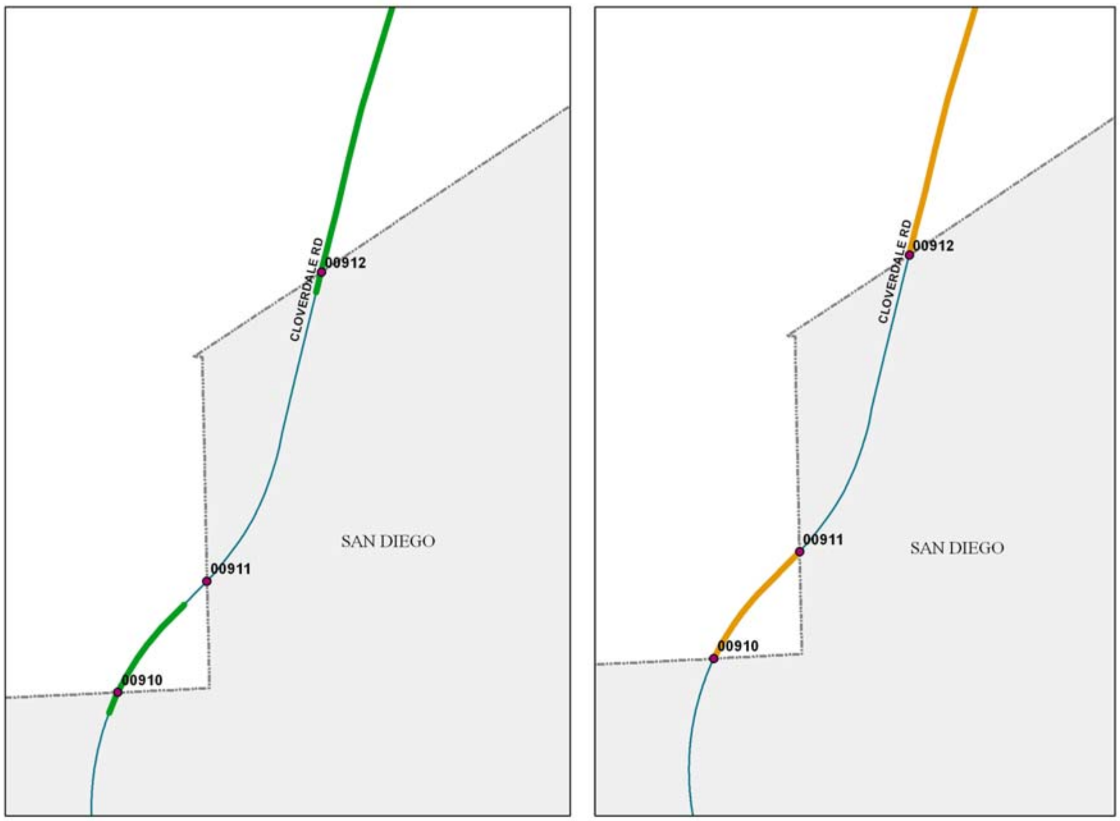

Figure 5: Example showing a route event for maintenance status. The County maintains the road in the unincorporated area, but not in the City. The uncalibrated route on left yields an incorrect map, with maintained portions shifted about 180 ft. Calibrating the route corrects the route event to properly match the City boundary.

When the routes are built and calibrated, it is possible to add many kinds of route events, e.g. signs, guardrails, maintenance status, pavement surface, and so on. These events are as accurate as the information stored in Hansen.

6) The Matter of Stewardship: Who keeps which data up to date and accurate?

We now have a base map that is better than 99% accurate. Using that, we can map any asset or attribute keyed to the road base if it is correctly recorded in our Hansen database. As we examine the data, we discover that there are instances where various asset and attribute information has not been updated to reflect changes in the roads. This appears to have happened because responsibility for maintaining the data is diffused within the organization. Each item of information in the database is, in theory, the responsibility of some individual, but we have discovered that in some cases the individual is not aware of the responsibility, or in other cases, the individual has undertaken to track the information using software other than Hansen. We are now working at doing the training and coordination necessary to ensure that information is maintained in the "system of record" so that queries and maps addressing that information will be accurate.

7) The Problem of Fragmentation: Some people use other software and then are not well integrated into a single system.

In some cases, sections have chosen to use software other than Hansen to maintain databases or perform analysis.
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The pavement management section has chosen to use the Corps of Engineers' Micropaver software, in lieu of pavement management modules in Hansen. That section draws information from the Hansen and GIS road and surface databases to use as input to an analysis process embodied in the Micropaver software. Pavement condition is surveyed every 4 years, with a contractor chosen to drive all county roads with specially equipped trucks that photograph the entire pavement surface and the surrounding areas while collecting a GPS trace. Analysis for pavement maintenance planning is done entirely in Micropaver. When paving projects are done, work orders are created and appropriate history and other records may be created in Hansen by the Road Registrar. However, pavement condition information is not fed back into Hansen.

The traffic division tracks accidents on County roads and needs to analyze patterns of accidents relative to location on various road segments or close to various intersections. For this, they have chosen to use software called Crossroads. While Crossroads provides the analysis that the traffic division wants, it requires input that is different from the GIS layer we have created. Rather than using information attached to a segment or route, Crossroads looks for an actual crossroad in its road base layer. This necessitates maintaining a separate road layer with, for example, pseudo-roads added at mileposts. The pseudo-roads are short lines inserted in the road layer with the name of the milepost, so that Crossroads can find the road where the accident happened, the "crossroad" referenced, and measure from the crossroad to place the accident as a point. We are concerned that maintaining a separate layer will require extra work, and, over time, it will be difficult to maintain an accurate base. We are discussing with the traffic division how to convert them to using Hansen and the GIS road layer as it exists. This will require them to process their accident data in a slightly different way, and there are issues of confidentiality and security, though both of those issues are being addressed successfully.

When instances of traffic signals apparently being in wrong places were noted, we contacted the field staff responsible for signal maintenance. We learned that the signal man keeps his own database of signals in an Access database. We will be working with the signal man to either train him in the use of Hansen, or to develop a procedure for regular updates to Hansen from the Access database.

8) Sharing the information: the internal County network, County intranet IMS mapping, PDF files, and external internet.

Within the County organization, a limited number of staff has either Hansen or GIS software available, while the number of staff who need to use the information are many. For those with GIS software, GIS layers are made available on the SanGIS SDE and an internal SDE.

For those without GIS software, two avenues of access are provided: PDF maps and documents that may be viewed on shared network drives or via the County intranet, and an ARCIMS mapping application that is available on the County intranet.

ESRI Production Line Tool Set (PLTS) has been used to create a map book format to show the County road system at 2000 ft/in using CALTRANS California Road System (CRS) grid system. The map book is printed to a series of PDF files, one file per CRS cell. The PDF maps lend themselves to easy access both internally by County staff and externally by the public. A key map shows the CRS grid overlaid on a map of the County for those who want to view a given area, and a road-to-cell cross reference table has been generated by intersecting roads with cells, producing an index to be used by those who want to view a particular road and want to know which map to reference. The key map below is visible to County intranet users, and also to the public on the County's internet web site. The user may click on a cell, and the web page will then display the PDF map of that CRS cell.

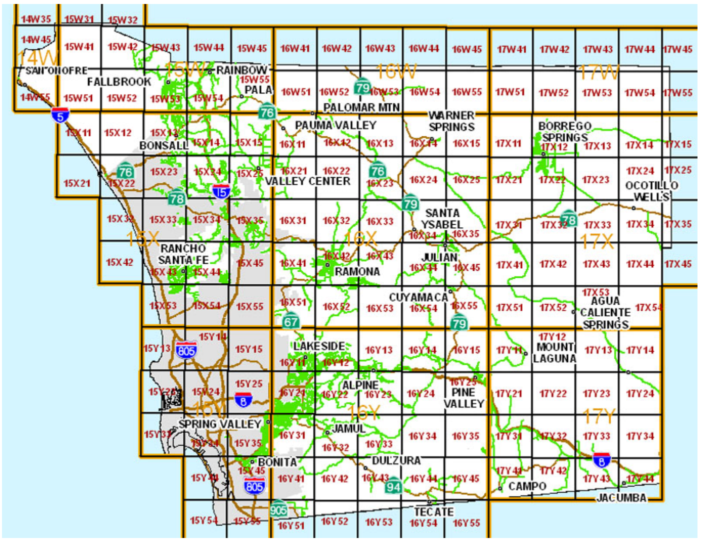

Figure 6: The CRS map index as used on intranet and internet sites enabling access to PDF copies of the PLTS CRS maps.

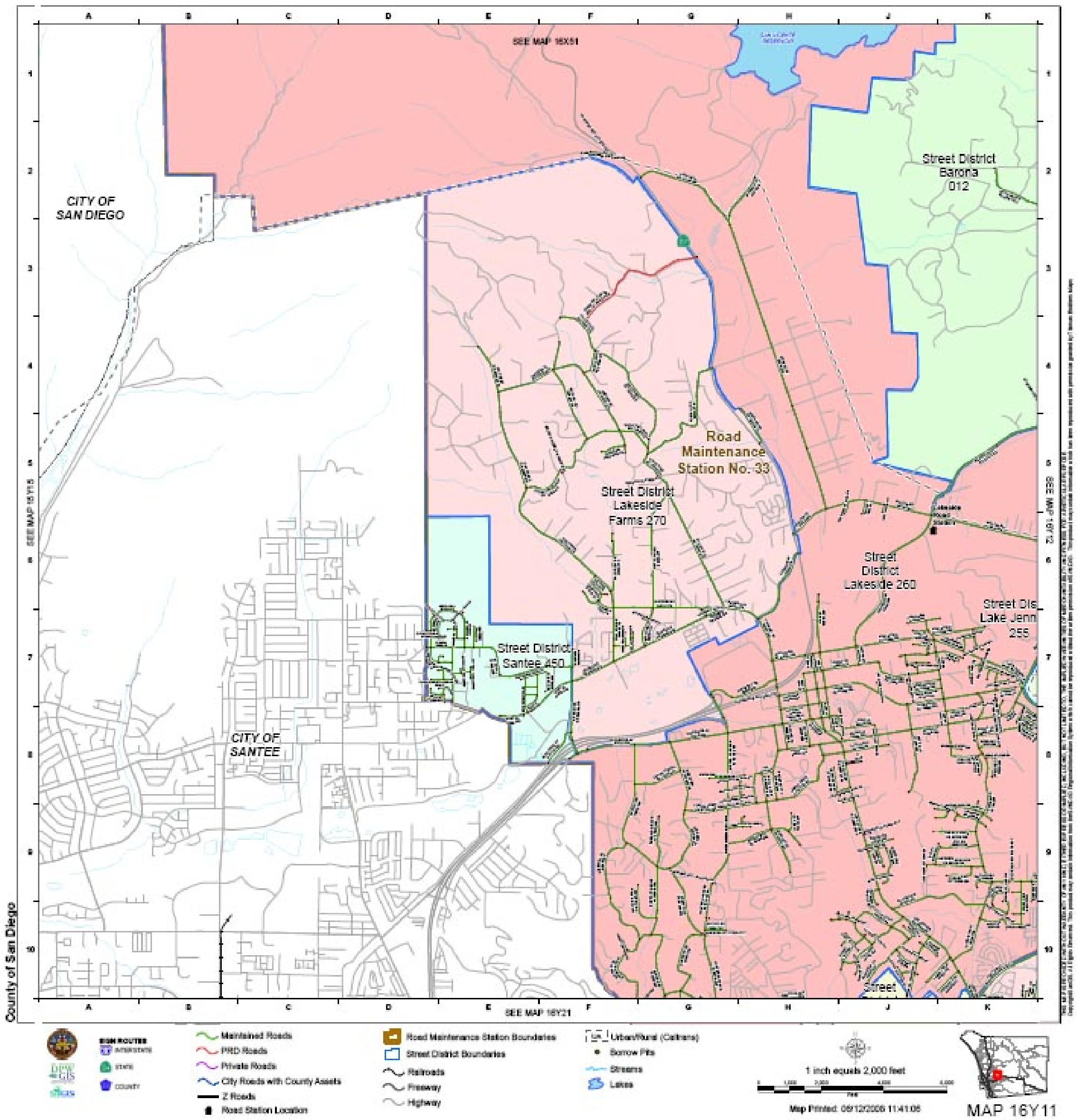

Figure 7: A sample CRS map. The web site serves a PDF file which will open in Adobe Acrobat Viewer. It may be searched, and it is possible to zoom in to view up close. This map shows incorporated areas to the left. On the right are parts of several County street districts with County maintained roads in green.

Also on the County intranet are a number of ArcIMS mapping applications are available for County staff to use. The County road system is presented as a number of layers in that mapping application. Staff seeking to know if a County maintained road serves a given area, or if a road is maintained may access the mapping applications using a web browser, and all County computers now have a browser installed, so any staff with access to a computer may view the County road system.

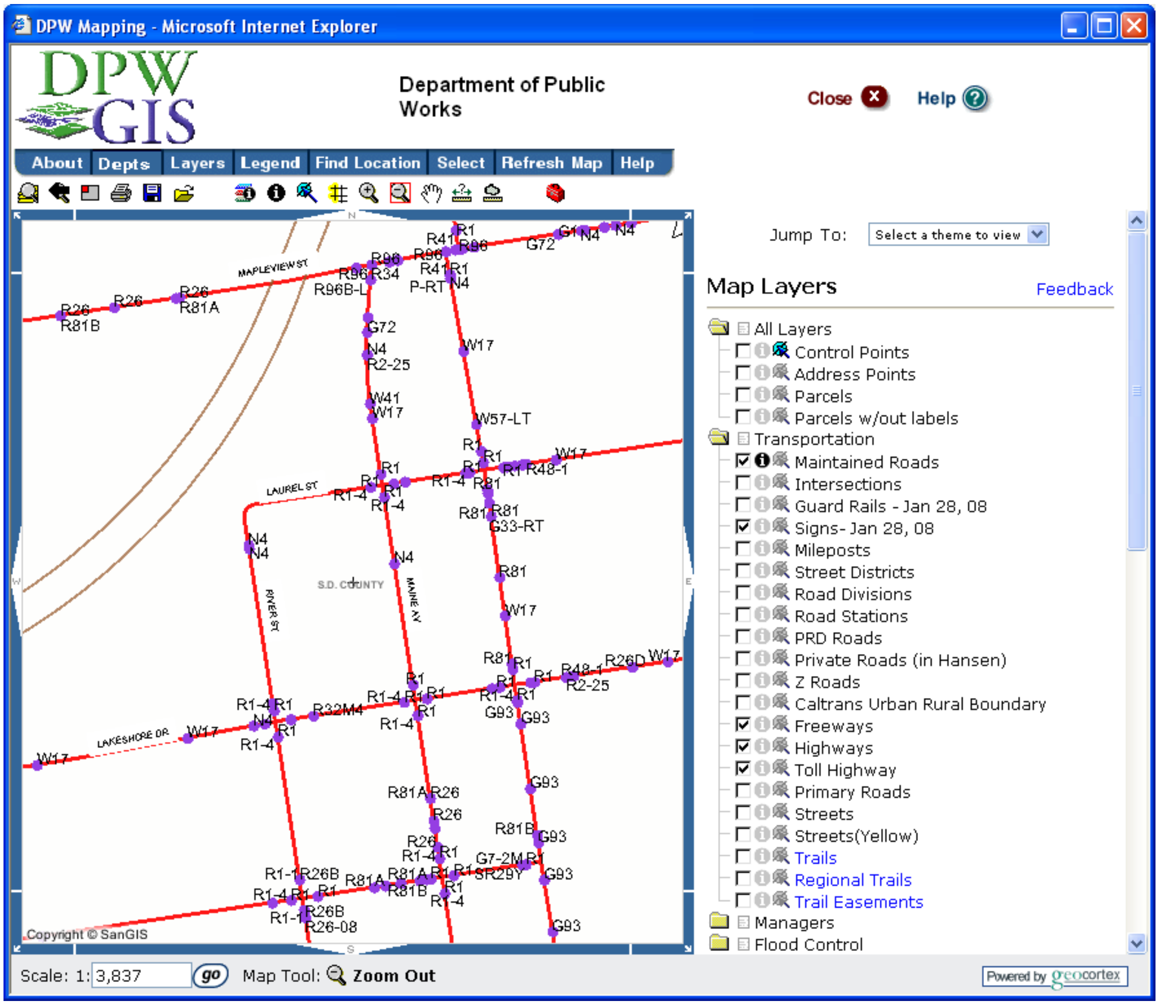

Figure 8: Screenshot of an ArcIMS map available to County staff on the County intranet. The red lines are County maintained roads. The brown lines are a State route. Dot with labels are signs. Various layers may be turned on and off, and detailed information is available by clicking on features with the "i" tool.

In addition to map book PDFs and the intranet ArcIMS application, several text or tabular documents have been converted to PDF and placed on network drives visible to all staff. E.g. official acceptance documents are stored on internal network drives for use by County staff. Many text documents, including the Road Register in PDF form, are also available to the public for viewing via the internet.

9) Summary

A legacy Road Register system has been migrated into the Hansen asset management system. Tables were modified and cleaned in the process to match Hansen's data model.

After the Hansen system went live, and County staff began using it, a GIS layer of County roads was developed. The County road GIS layer borrowed much of its geometry from the regional data warehouse road layer, but was modified as needed to reflect road realignments, discrepancies between road centerlines and aerial photos, and breaks where County maintenance ends. Segments, defined as a line from one intersection to the next, were matched between Hansen and GIS. Orphan segments were investigated and corrected. Length discrepancies were also investigated. Major discrepancies are corrected; for minor discrepancies route calibration is used to ensure that feature events map accurately.

The process of migration has resulted in extensive cleaning of the database. Digital distribution of data has greatly improved accessibility and currency of information compared to the old paper reports and maps that were published annually. We estimate that location and maintenance status of roads is now greater than 99% accurate.

The road base has been used to map various assets and attributes. Resulting maps have been reasonably accurate, but some errors in asset and attribute tables have been noted.

A challenge for the future will be to enlist responsible parties to maintain databases in Hansen and ensure that the information is current and accurate. A significant part of this effort will be developing protocols for work flow, and training staff in using the protocols and the software.