Using Satellite Technology to Develop a Sign Inventory Program

The City of Greeley has a population of 82,000 and is located 50 miles north of Denver, Colorado along US Highway 85. Over the next five years, the projected growth rate for the City of Greeley is over 17 percent. This continual expansion creates an increasing demand for the installation of traffic signs within the public right-of-ways and in new developments. City of Greeley, Transportation Services Division is responsible for maintaining over 15,000 Traffic Signs. With the demand for new sign installation and the need to maintain existing signs, the City needed a system to accurately track the total number of signs, the type, the condition and the geographic location of each and every traffic sign in the City.

Starting in 2000, the Transportation Services Division began implementing a Global Positioning System (GPS) Inventory Program. The GPS-based data collection system, allows a Geographic Information System (GIS) database to be created and all of the sign information can be collected for each sign. The GIS information provides an accurate geographic location of a specific sign and records attributes for each feature. The (GIS) technology has revolutionized the mapping and tracking of assets for local government. A GIS database allows for large quantities of spatially referenced data to be stored, managed, analyzed, and queried. The database utilizes ArcView GIS, a type of software for desktop GIS and mapping created by ESRI (Environmental Systems Research Institute). Various local, state and federal governmental agencies have utilized the GPS-based data collection for inventory purposes across the United States and around the world. For example, the City of Garden Grove in Orange County, California is utilizing a GPS-based data collection and analysis techniques for the inventory of traffic signs along their arterial roadways. Aurora, Colorado uses GPS technology to map and evaluate sidewalks, curbs and roadways for maintenance management. The applications for GPS data collection are limitless existing in almost every field ranging from transportation, surveying, natural resource management, commercial business, and agriculture.

Basic Operating Principles of GPS

GPS is a satellite-based system that provides accurate spatial locations and timing information. The US Department of Defense developed GPS as a navigation system for military use. The technology became available for civilian application, but with a selective availability that introduced ephemeris errors. These errors caused position errors up to 100 meters for security reasons. On May 1, 2000 selective availability was discontinued. This increase in accuracy made GPS more applicable to civil users. Although Basic GPS is the most accurate radio-based navigation developed, differential corrections are made to correct any inaccuracies in the GPS system allowing accuracy to increase even further. There are two main elements of GPS, space and user segments. The space segment consists of 27 satellites in six orbital planes orbiting approximately 20,000 km (12,000 miles) above the earth’s surface. (Figure 1) Ground stations worldwide continuously monitor these satellites.

These satellites send out radio signals to exact their location. Once a user with a GPS receiver on the ground in an unknown location is able to connect to four or more satellites, an exact geographic position can be triangulated from the position of the satellites within a sub-meter of accuracy. Constant improvements in GPS technology are being made for equipment, positioning, and navigation and timing.
Procedure

The City of Greeley Sign Inventory Program involves the collection and processing of inventory and conditional data through the use of high precision specialized GPS units. Currently, Transportation Services utilize two Trimble GPS Pathfinder Pro XRS units for GIS applications. (Figure 2)

The Pro XRS model allows for sub-meter accuracy and real-time differential technology. This type of unit allows for accurate field data collection and better accessibility with its backpack design. The unit consists of a bulb antenna feature that connects to orbiting satellites, and a handheld data collection unit (TSC1) that collects line, point, polygon features and the attribute information of each feature.

Local governments have thousands of fixed assets throughout cities such as traffic signs, signal lights, streetlights, trees, water/sewer lines, and other natural resources. These organizations must be able to accurately locate and maintain these assets. Information of these assets can be collected in the field with the handheld data logger in the form of features and attributes. A feature is representation of a physical object, which requires an exact location and attribute information attached. An attribute is information about a feature. A data dictionary is a description of these features and attributes and is used to control the collection of attributes. Each physical traffic sign is displayed as a point feature with attribute information. Each attribute has a corresponding menu in which information can be entered. For example, while collecting data in the field, a poor or good rating pertaining to the reflectivity or condition of a sign can be entered. (Figure 3)
The City of Greeley is currently divided into 10 maintenance districts. Each district is divided into separate sections (Appendix A). To begin the data collection process, a map of a section within a specific district is printed as a guide. Sign labels, displaying identification numbers are created for that district and section, and printed. The GPS specialist then drives to the location and begins the data collection process. By following the map, each sign that is visually located is inventoried. The unit is turned on and the specialist waits for the GPS unit to connect to the satellites given the proper conditions. If problems occur during satellite connection, trouble-shooting procedures are taken. Once the GPS unit has connected to the satellites, the data collection can occur.

In the first step of the inventory procedure, a specific identification number is attached to the sign. To insure the identification label is securely attached to the sign, the label is covered with an adhesive spray. Next, an individual GPS point is taken for each sign present on the post. Then, the sign is visually assessed for discrepancies such as poor sign rating; poor reflectability, poor post condition, or visibility obstructions. All information is entered for each attribute. When all of the data is collected, the specialist moves on to the next sign to be inventoried.

After the collection is completed, the data is transferred from the data logger into Office Pathfinder software program (Figure 5). The basic GPS file is then differentially corrected, and then exported into the GIS ArcView program. The GPS data can then be corrected, analyzed, and queried in order to produce a report of the data in tabular or map format. (Figure 6)

**Inventory Data**

The data collection and inspection process took over one and one-half years to complete. Two full time Technicians on one inspection team and additional seasonal GIS Technicians made up a second team. Aims Community College has a very good GPS program and certifies their graduates, and was an outstanding resource in this process. The data collection began in July of 2000. The Technicians were able to actually record GPS points for 5 to 6 hours per day given the satellite alignment that is need for accurate data collection. The results of the inventory are illustrated in Table 1 (on page 33).
As you can see there are several categories of signs, Regulatory, Guide and Warning signs are the 3 major types of signs that are used throughout the City.

These are examples of Regulatory Signs.

Guide Signs help you find the location for which you are looking.

Warning Signs give advance notice of road conditions ahead.

Isn’t your old dog still comfy?

Your old “doggy” traffic system still does the job, too.

The comfort of familiarity cannot be denied. You know your old traffic system like the back of your hand. You know its strengths and weaknesses. If there is a problem, you know where it is most likely to be. And you know how to fix it, or at least get passed it.

If you need the parts to keep your “old dog” running strong, call us at OMJC. We have the equipment you need, all refurbished, tested, and guaranteed for one full year. Our parts won’t give you new capabilities or add pizzazz. They will look good, and run reliably. And that’s comforting. Because at OMJC, we believe in appropriate technology.
Inspection Data
The sign inspection was completed at the same time the GPS points were being collected. Each sign was visually inspected during normal day light conditions. The signs were then evaluated as to condition and a quality rating was assigned. Many signs were rated in the Poor category; approximately 21%. (Table 2.)

<table>
<thead>
<tr>
<th>District</th>
<th>Good Condition</th>
<th>Poor Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,474</td>
<td>402</td>
</tr>
<tr>
<td>2</td>
<td>2,509</td>
<td>925</td>
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<tr>
<td>3</td>
<td>1,821</td>
<td>650</td>
</tr>
<tr>
<td>4</td>
<td>2,054</td>
<td>693</td>
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<tr>
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<td>1,675</td>
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<tr>
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<td>7</td>
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<td>8</td>
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<td>27</td>
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<td>9</td>
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<td>8</td>
</tr>
<tr>
<td>10</td>
<td>42</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>11,887 (79%)</td>
<td>3,200 (21%)</td>
</tr>
</tbody>
</table>

Data as of 7/1/2002

Maintenance Program
The replacement of the signs rated as poor will be accomplished by using a systematic approach, starting with the replacement of the signs in District 1 and progressing throughout the City. After all of the signs rated as poor have been completed in each district, a nighttime visibility and reflectivity inspection will be completed and any additional signs that fail this inspection will also be replaced in that area.

The estimated cost to replace all of the signs rated as poor could be as high as $194,000 not including inflation. Even with completing this level of work the City is lagging behind in needed maintenance. The Traffic Sign Section will have to take a “back to basics” approach to maintain the traffic signs at an acceptable level of service. Staff has taken several steps to get back to basics, in that sign maintenance crews no longer install signs in new developments.

The Division also has been contracting the fabrication of large Bond/Food Tax Project Signs out to the private sector. On large sign installation projects such as the Hospital Guide Sign Project, staff ordered the signs pre-fabricated rather than fabricating them in house. This procedure has saved time and money.

With a shifting of priorities Staff has been able to improve our sign maintenance program. However, based on present funding levels Transportation Services may not be able to respond to the demand for new signs as our customers have become used to in the past. i.e. Neighborhood Traffic Calming Program, Traffic Safety Improvements and requests from various Departments as well as construction projects.

Food Tax Projects Funding has greatly increased the City’s ability to maintain the signs in the past. In 2002 Food Tax contributed $25,000 for the first year of the maintenance program. All of the Poor Rated Signs have been replaced in District 1, Section 1 and in District 2, Sections 1, 2, and 3 (Appendix B). There were 491 signs replaced in the first year of the maintenance program. Transportation Services is anticipating that this funding source will be able to continue to assist in bringing the traffic signs into compliance in the upcoming years.

The maintenance program will allow for all poor signs throughout the city to be replaced, and to meet new sign specifications required by MUTCD. This effort will dramatically improve the sign quality for the City of Greeley.

Maintaining the Database
Each time a sign is replaced, removed, relocated or added the GPS data must be updated. Keeping the database current requires attention. A delay in time exists between the replacement and installment of a traffic sign occurs in the field and entering the updated information into the database. The process that is currently utilized involves gathering work order forms that detail the action performed, and then entering the data into the GIS database on a monthly basis. This process is time consuming and creates a delay for the access to more accurate information. In order to improve staff’s ability to properly maintain the GIS database, Transportation Services Staff is in the process of equipping our technicians with the portable GIS ArcPad Software and Compaq Palm Pilot (Figure 7, page 35).
Conclusion

The City of Greeley has thousands of fixed assets that are maintained by the Transportation Services Division, such as traffic signs, traffic signals and pavement markings, which require inventory in order to improve our maintenance and provide more accurate locations and identification data. With the completion of the GPS-based data collection process, approximately 15,100 traffic signs were inventoried throughout the City of Greeley.

The Sign Inventory Program is an on-going process, with the addition of new sign installations and continuous replace maintenance; the sign information is constantly changing.

With the continuous growth and expansion of the boundaries in City of Greeley, the use of GPS technology will allow city personnel to accommodate the demands of the installation of new traffic signs and other assets, maintain existing signs, and perform future replacements in compliance with the Manual on Uniform Traffic Control Devices (MUTCD) Millennium Edition. The addition and utilization of new and advanced GPS and GIS technology will assure the success of current and future projects.

Based on GIS and Sign Inventory data, several sign placement proposals were made for hospital, city limits, and the Poudre River Trail Corridor. The Department has started a Maintenance Replacement Program for all of the poor rated signs. The Sign Inventory data can be utilized to determine a wide range of information. For example, a time table displaying the deterioration of signs could be calculated based on the installation date and the date of sign replacement. The Sign Inventory Program is also beneficial to other city divisions that require sign information. Transit Services recently requested GPS/GIS data on existing bus stops throughout the city, and a street lighting inventory.

Currently, there are recommended requirements for retro-reflectivity standards provided by FHWA, however, these standards are not required at this time. When these Federal mandates are instituted in 2004, additional equipment will also be needed in order to update the inventory as sign assets are changed to meet new Manual on Uniform Traffic Control Devices (MUTCD) requirements for improved retro-reflectivity and larger letter sizing for signs. It remains one of staff’s top priorities to maintain both day and night time visibility, this program has provided to the City the ability to manage the sign system with increased reliability and accuracy.

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