Development of a GPS-Based Sign Inventory Tool for Iowa's Statewide Management System

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May 2011

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The mission of the Center for Transportation Research and Education (CTRE) at Iowa State University is to develop and implement innovative methods, materials, and technologies for improving transportation efficiency, safety, and reliability while improving the learning environment of students, faculty, and staff in transportation-related fields.

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16. Abstract

This report is on state-of-the-art research efforts specific to infrastructure inventory/data collection with sign inventory as a case study. The development of an agency-wide sign inventory is based on feature inventory and location information. Specific to location, a quick and simple location acquisition tool is critical to tying assets to an accurate location-referencing system.

This research effort provides a contrast between legacy referencing systems (route and milepost) and global positioning system- (GPS-) based techniques (latitude and longitude) integrated into a geographic information system (GIS) database. A summary comparison of field accuracies using a variety of consumer grade devices is also provided.

This research, and the data collection tools developed, are critical in supporting the Iowa Department of Transportation (DOT) Statewide Sign Management System development effort. For the last two years, a Task Force has embarked on a comprehensive effort to develop a sign management system to improve sign quality, as well as to manage all aspects of signage, from request, ordering, fabricating, installing, maintaining, and ultimately removing, and to provide the ability to budget for these key assets on a statewide basis.

This effort supported the development of a sign inventory tool and is the beginning of the development of a sign management system to support the Iowa DOT efforts in the consistent, cost effective, and objective decision making process when it comes to signs and their maintenance.

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DEVELOPMENT OF A GPS-BASED SIGN INVENTORY TOOL FOR IOWA'S STATEWIDE MANAGEMENT SYSTEM

Final Report
May 2011

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INTRODUCTION

The Iowa Department of Transportation (DOT) is committed to infrastructure management and understands the potential benefits from implementing a sign management system. Given the diverse range of driver needs within the state, the Iowa DOT has established an agency goal of developing a sign management system that:

- Improves the quality of signage out on the roadway network
- Improves the ability to manage all aspects of signage from request, ordering, fabricating, installing, maintaining, and ultimately removing
- Improves the ability to budget for these key assets on a statewide basis
- Provides a tool for decision makers to do signage-related scenario planning

To accomplish these goals, the Iowa DOT has established a Sign Management Task Force, which has focused on a number of issues including field survey and inventory, location/reference and integration, and the development of sign inventory analysis and management tools. As shown in Figure 1, the variety and density of signs along any given route can vary significantly.

Figure 1. Sample sign variety and density (along US 30 in Carroll County, Iowa)

This report covers the Task Force efforts to address issues related to referencing sign locations as part of the inventory-building process. This research provides a contrast between legacy referencing systems (route and milepost) and global positioning system- (GPS-)based techniques (latitude and longitude). A summary comparison of field accuracies using two GPS devices is also provided.

FIELD STUDY

The Task Force had numerous discussions about recording a sign location either through route and milepost indicators or through global positioning system (GPS) coordinates. Based on these discussions, there were a number of reasons why GPS coordinates were felt to be the preferred method for field inventory efforts. The reasons included the fact that referenced route and mileposts can move over time (when a route is reconstructed) making it difficult to track the same spot over time. Additional reasons included the idea that GPS also offers a reduction in the potential for human error, whether it be basic data entry, measurement along a route in terms of offset from mileposts, or where issues arise due to referencing along concurrent routes or along ramps and other unusual areas.

With an anticipated recommendation to use GPS equipment for referencing sign locations (as part of initial inventories), several different field studies were conducted to compare the two methods. The following discussion summarizes this effort.

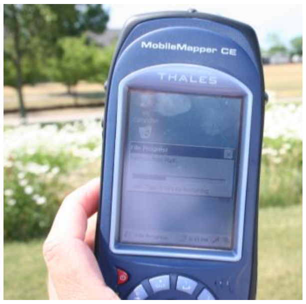
Sign Management Field Review

The objectives of the field review(s) were to assess the relative differences between milepost-based sign locations as opposed to the same sign locations as collected with both a low- and high-cost GPS receiver. The evaluation considered the potential impact of inaccurately geo-referenced mileposts, general field data collection procedures and issues, and consistency in the sign-inventory database. In addition, an absolute accuracy assessment of the GPS equipment was conducted at two High Accuracy Reference Network (HARN) locations.

Two different field evaluations were conducted within the Iowa DOT District 3. Sign locations on rural and urban portions of two different routes (one with a concurrency) were collected. The existing route and milepost inventory information, used to compare with field GPS readings, were inventoried by different DOT staff within District 3. The two field evaluations conducted as part of this study collected GPS coordinates for 110 posts and 91 posts, respectively. The equipment used for these studies consisted of two Bluetooth-enabled GPS receivers, which were held at each sign post where an average of 50 satellite readings were obtained through use of the ArcPad software on two different laptops.

The two GPS receivers included a higher-cost Thales unit, which cost roughly $3,000 (including mapping software), and an i-Blue navigation unit, which cost roughly $100 (with no software included). Both units transmitted satellite information (in National Marine Electronics

Association/NMEA format). Figure 2 provides additional information on each unit. Figure 3 illustrates an example of the field demonstration method.



General features for Thales Mobile Mapper™ CE

- WAAS enabled
- NMEA format
- Bluetooth capable
- 1. 0m static CEP 95
- Roughly $3,000 (mapping software included)

General features for i-Blue™

- WAAS enabled
- NMEA format
- Bluetooth capable
- 3. 0m static CEP 95
- Roughly $100 (no software included))

Figure 2. GPS units and brief specifications used (Thales unit on left, i-Blue on right)

Figure 3. Sample illustration of field demonstration method

Field Evaluation Locations

Figure 4 provides maps of the two study areas where the field demonstrations were conducted. The red dots indicate the locations where GPS readings were obtained.

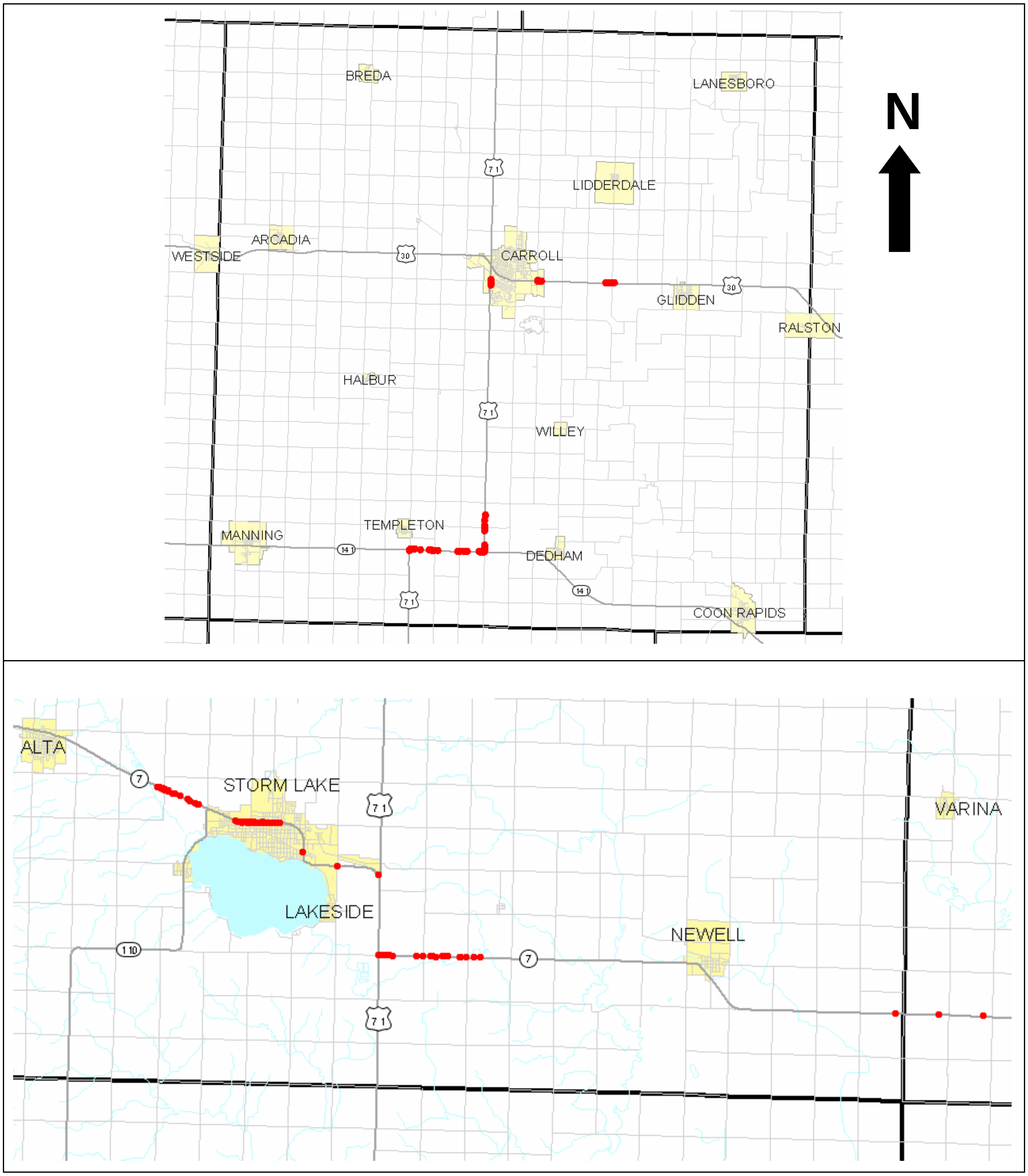


Figure 4. Field evaluation locations in District 3 (Carroll and Storm Lake, Iowa) *(1)*

These two different locations were selected to include areas where different DOT crews had previously completed the milepost-based inventory. Each study included signs within both urban and rural settings.

ANALYSIS

Results

The existing route and milepost inventory information was contrasted with that collected using the two GPS devices in a geographic information system (GIS) format. Figure 5 shows a comparison of the Thales GPS-based inventory to the milepost-based inventory for the Carroll, Iowa field study. As shown, there was a 53.4 meter average difference between the two inventories.

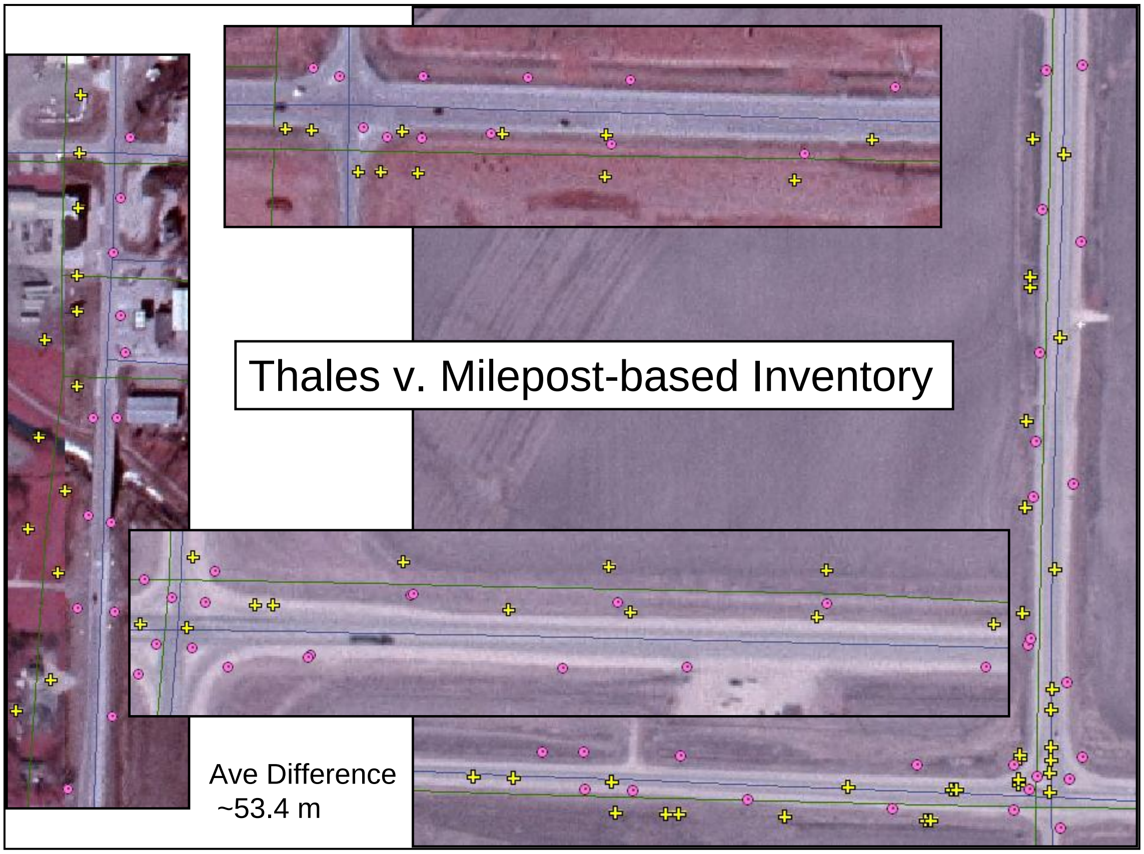


Figure 5. Thales GPS unit versus milepost-based inventory (Carroll, Iowa) ***(2)***

As with all of these comparisons, some of the differences in location can be attributed to the fact that milepost-based sign locations were geocoded along a cartographic representation of centerline possessing an accuracy of 50 meters. In addition, the actual milepost locations were derived from several data sets, including the interpolation of coordinate data associated with video log van frames (possibly, for multiple years) and the now defunct milepost-geographic information management system (-GIMS) milepoint cross reference table.

Furthermore, the GPS-based locations were recorded at the actual signpost locations, rather than their projection on the centerline. Finally, inaccuracies and inconsistencies exist in field measurement. For example, in the existing sign inventory, not all mileposts are used as reference markers. In some cases, all signs were referenced based on a cumulative mileage from a single milepost, which could be several miles away from the sign being inventoried. Given that each milepost may not be located exactly one mile apart, such a practice leads to error propagation, even when using a highly-accurate, distance-measuring instrument (DMI). Each sign should be referenced to one of the two nearest mileposts.

Figure 6 shows the same comparison for Carroll, Iowa using the i-Blue GPS receiver. As can be seen, the average difference between the two methods is 53.6 meters. When the inventory from the two GPS units were compared, the average difference in location was only 4.6 meters (See Figure 7). This shows that the two GPS units are getting consistent results and both are locating signs within a limited tolerance.

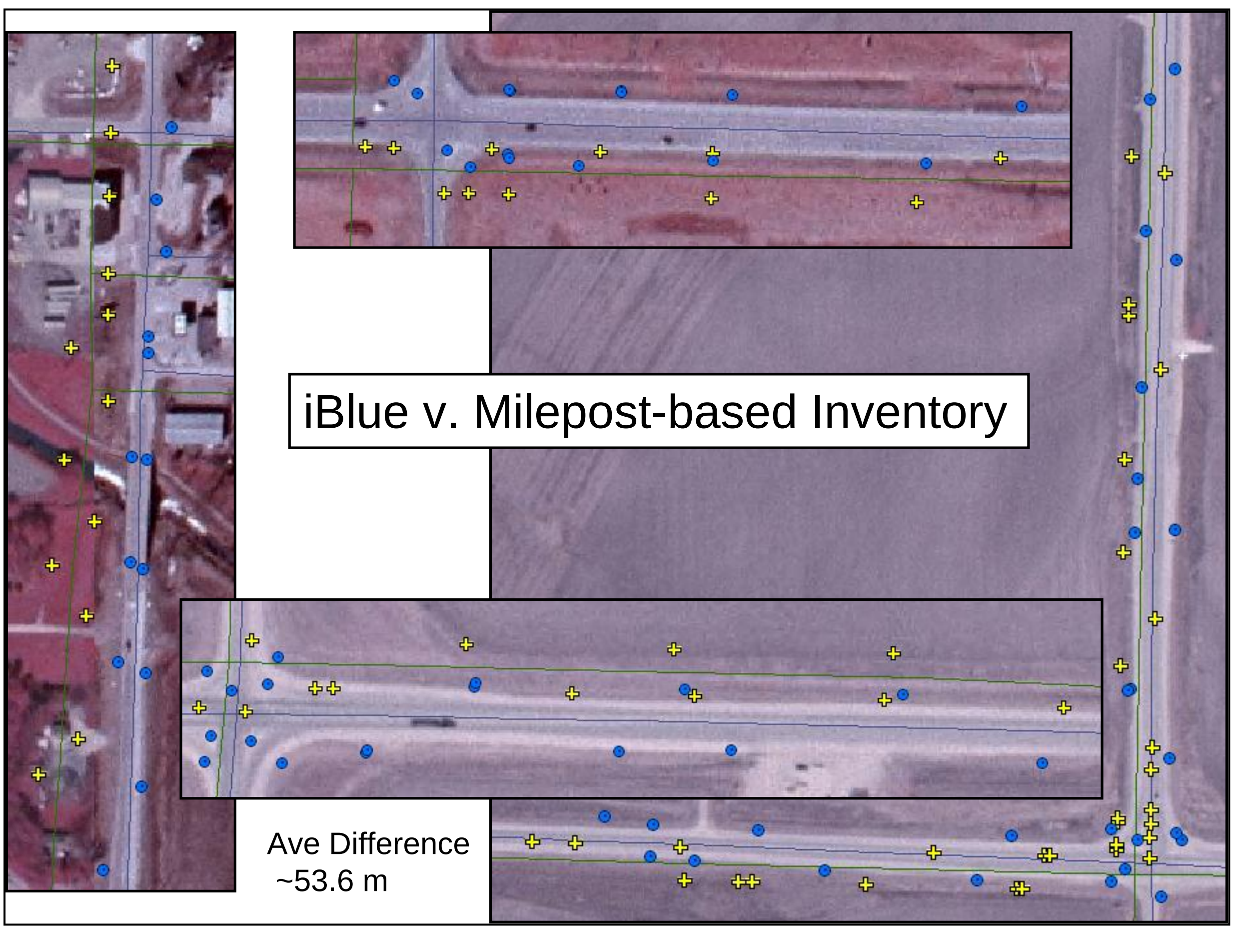


Figure 6. i-Blue GPS unit versus milepost-based inventory (Carroll, Iowa) *(2)*

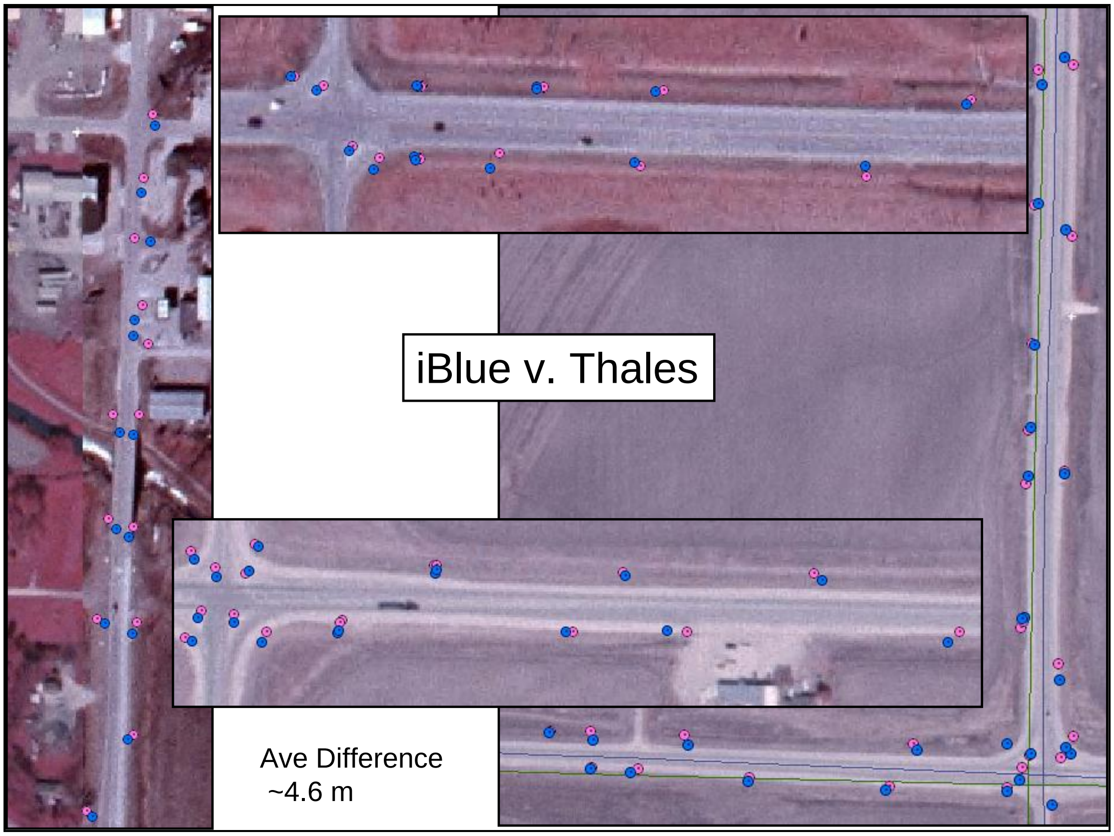


Figure 7. i-Blue versus Thales GPS units (Carroll, Iowa) *(2)*

The same process was repeated for the second evaluation area (Storm Lake, Iowa) with the results summarized in Table 1. As shown, the difference between the GPS-based and the milepost-based inventory decreased, from the Carroll study, as did the difference between the two GPS units. During data collection for the second field evaluation, the GPS units were allowed 5 to 15 seconds to re-acquire before recording at each location. That process improved the relative accuracy of each device and resulted in less (average 3.2 meters) difference between the two units. In both field reviews, the low-cost GPS receiver yielded results within 5 meters of the higher-cost unit.

Table 1. Field evaluation comparison (GPS- and milepost-based inventories) *(2)*

	Carroll (n = 110)			Storm Lake (n = 91)		
Difference	**i-Blue vs. Thales**	**i-Blue vs. MP**	**Thales vs. MP**	**i-Blue vs. Thales**	**i-Blue vs. MP**	**Thales vs. MP**
AVE	4. 64	53. 56	53. 43	3. 24	36. 54	36. 01
STDEV	3. 18	27. 95	27. 94	2. 56	32. 53	31. 76
MIN	0. 39	1. 89	4. 78	0. 37	4. 27	6. 92
MAX	17. 43	149. 04	148. 09	14. 58	183. 97	184. 94

All values are in meters

GPS Equipment Comparison

GPS accuracy and repeatability were assessed at two known HARN locations. An average of 50 satellite readings were collected over multiple days, with forced satellite reacquisition for additional data collection each day. In general, each GPS receiver yielded accuracies near vendor-provided specifications. Review of each independent satellite reading (comprising the averaged 50) indicated that the position processing algorithms of the more expensive unit appeared more advanced, as would be expected. Figure 8 shows the two GPS comparison at the two HARN sites.

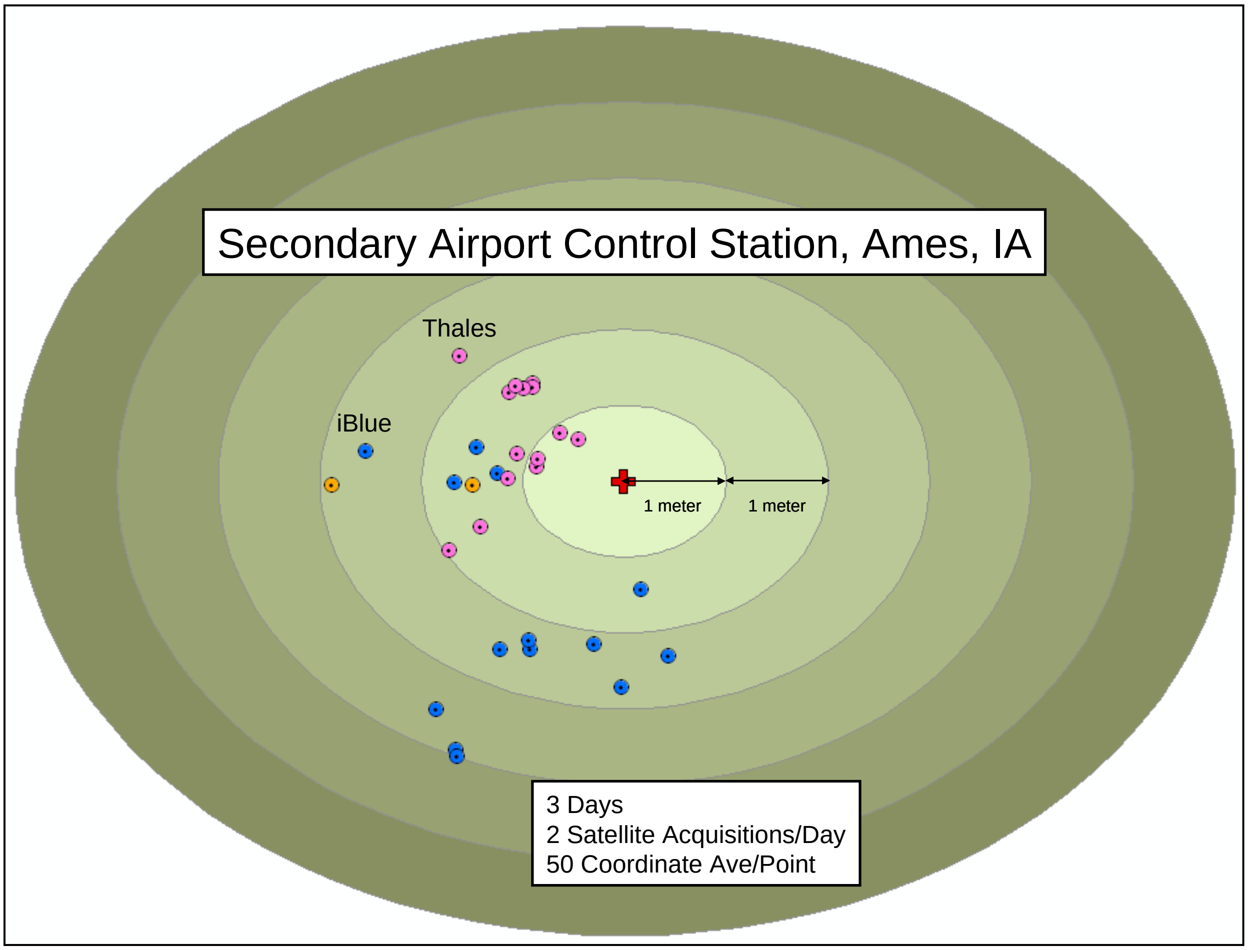


Figure 8. Comparison of GPS units to a High Accuracy Reference Network (HARN) site (Ames, Iowa) *(2)*

SIGN INVENTORY TOOL

The need for a single statewide inventory and database format became clear when reviewing the variety of formats and file types found among two individual Iowa DOT districts that had varying forms of a sign inventory. One district's inventory contained more than 29,000 records with more than 4,900 unique Sign Message values identified, many of which are redundant. For example, it included 129 variations for referencing a Yield sign (with abbreviation and/or spelling variations) *(3).*

Establishing a common format for sign information was critical in supporting inventory, performance tracking, and management on a statewide basis. Given the significant variety of signs and the staggering inventory on the DOT system, the Task Force needed to be specific as to which objects were considered to be signs and, of these, which were to be included within a sign management system.

For example, should the system include ROW or mowing signs, delineator buttons, weight station electronic open/close signs, and so forth? The group felt that the management system should focus on signs that convey information to the motorist (as opposed to maintenance and DOT staff) and that are contained within the Iowa DOT Sign Catalog. The group anticipates that logo signs would be in a separate database and would have a common identification system for mapping. Parks and Institutional roadways were expected to be included within the sign inventory; however, referencing of location would be by sections.

The Task Force drafted a list of standard inventory features and solicited input on the list from each district. A sample of the resulting standard inventory items are shown in Figure 9 *(3).*

LOCATION/POSITION	**SIGN**
District	Sign Category
Maintenance Garage	Sign Description
System Class	Size
Route Number	Sheeting
Ramp Number	Blank Material
	Date Inistalled (optional)
POSITION	Direction Sign Facing
Lattitude, Longitude	
Milepost, Offset	**SIGN CONDITION**
Direction of Travel	Day or Night Inspection
Side of Road	Date
Lateral Offset (optional)	Rating
Comment (optional)	Retroreflectivity (optional)
	Comment (optional)
POST	Flag/Beacon/Etc. (Optional)
Post Type	Ownership (Optional)
Post Size	Inspector
Number of Posts	
Number of Signs	
Length of Posts (optional)	

Figure 9. Standard sign inventory items

Based on field research, a decision was reached to reference sign location by GPS with milepost and offset as a backup method.

The Center for Transportation Research and Education (CTRE) developed a software tool was to assist district crews in collecting sign inventory information (See Figure 10) *(3).* The tool focused on reducing input error and increasing field efficiency by minimizing pick list choices, based on previous inputs. The tool allows for averaging of GPS readings in the background while post and sign information is entered. The tool allows for simple queries and editing of the sign data and includes the option for both daytime and nighttime condition ratings.

Figure 10. Sign inventory collection software tool

The Sign Management Task Force is currently developing a list of desired management functions (See Figure 11 for the sample list) *(3)*, queries, mapping styles, and other features for the sign management system. Once complete, the group will assess if these features exist through off-the-shelf software or if a need exists to expand the existing tool functionality to include the desired management functions and other features needed to make the inventory tool more of a sign management function.

At all Levels (Field/Garage/District/Central Office):

a. History of the sign
b. Queries by location, post, and sign feature

Field/Garage Operations Capabilities:

a. Collect inventory data
b. Update existing sign inventory data: (on an existing post)
    i. Add a sign
    ii. Modify a sign
    iii. Remove a sign
    iv. Update sign condition (day or night)
    v. Other sign maintenance actions
c. Update post inventory data:
    i. Add a post (requires adding signs)
    ii. Modify post information (requires location confirmation)
    iii. Remove a post (also eliminates signs)
    iv. Other post maintenance actions
d. Locate a post in the field (using GIS, GPS, or paper print-out)

District / Central Office Capabilities:

a. Report showing query results in graphical or tabular format:
    i. Example – Sign condition by type/route/etc.
    ii. Example – Number of signs by type
b. Cost and Needs Estimates

Figure 11. Sample management functions

CONCLUSION

The field evaluations summarized within this report were conducted in an effort to support Iowa DOT staff in conducting sign inventories on a statewide basis. The differences found in referencing sign locations using mileposts and offset as opposed to GPS were demonstrated. Based on mapping and comparing the results of two separate field evaluations, it was concluded that GPS-based inventory is a preferred methodology over milepost. This report summarizes the differences between both the GPS- and milepost-based referencing, as well as between the two different GPS devices used to collect sign position.

This effort supported the development of a sign inventory tool and is the beginning of the development of a sign management system to support the Iowa DOT efforts in the consistent, cost effective, and objective decision-making process when it comes to signs and their maintenance.

REFERENCES

1. Omar Smadi, Zachary Hans, and Neal Hawkins. GIS Use in Pavement Marking and Sign Management: An Integrated Approach. Proceedings of the International Conference on Civil, Construction, and Building Engineering, Montreal, Canada, 2006.

2. Neal Hawkins and Omar Smadi. Sign Inventory: Legacy vs. New Technology. Presented at the 2007 Transportation Research Board Traffic Control Devices Committee Meeting. January 2007.

3. Neal Hawkins and Omar Smadi. *Sign Management System-Phase I Report*. Prepared for the Iowa Department of Transportation. January 2007.