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16. Abstract

Over many years, Global Positioning System (GPS) technology has been adopted by different sections within the Louisiana Department of Transportation and Development (DOTD), with no uniform standards for accuracy, operation, hardware, or software. As a result, it was unknown who was using GPS, what makes and models were being used, and for what purposes. The current state of GPS within the Department needed to be assessed and compared with current best practices as defined by use within the Department, other large agencies, and the GPS industry. Surveys and interviews of GPS at DOTD, other organizations using GPS, and vendors of GPS technology have been utilized to formulate management concepts to be considered as best practices for GPS usage at DOTD.

The goal of this project was to create a management plan to guide the Department's use of GPS technology into the future, based on best practices. The plan proposes at least one high quality GPS receiver at each district office and several for sections located at DOTD headquarters. Receivers are to have laser range finders so points can be collected faster and at safe distances.

The plan also proposes GPS management through the implementation of a GPS technology committee within DOTD, comprised of GPS users and GPS technology support staff. The committee will drive the overall vision of GPS usage and set standards for databases, operating procedures, coordinate accuracy, and training. Executing the plans will be a GPS coordinator (either a new position or modification to an existing position). The coordinator will also maintain an inventory of GPS units and manage device maintenance and upgrades.

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LTRC appreciates the dedication of the following Project Review Committee Members in guiding this research study to fruition.

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ABSTRACT

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IMPLEMENTATION STATEMENT

DOTD should adopt the "LADOTD GPS Technology Management Plan" developed as a result of this study and implement the recommendations in the plan accordingly. Existing practices of using recreational-grade GPS devices and handwritten forms need to be eliminated and a streamlined data flow process should be adopted, allowing field collected data to be rapidly uploaded and used. Safety will be improved by using laser range-finders allowing data collection from safe locations.

A new section should be added to the DOTD Policies and Procedure Manual (PPM) that establishes the authority of a GPS oversight committee to guide the implementation, give continuous review, and update standards for GPS technology. This should include software, equipment, data formats, and collection methods. It should also establish a GPS coordinator role to execute committee guidelines, maintain equipment inventory, and maintenance schedules.

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INTRODUCTION

Many sections within DOTD have been using GPS technology to collect locational data for their individual missions. Due to the unfettered adoption of GPS technology within DOTD by individuals with little or no training in the use and limitations of GPS, no uniform standards exist within the Department. This is the case for all aspects of GPS technology, including its use, procurement, training for users, and maintenance of GPS hardware and software. A troubling result of this is that most GPS data collection within the Department is being performed using substandard devices that are not designed by their manufacturers for the type of geographic data they are gathering.

Some of DOTD's GPS users are content with the current situation because their only use of the latitude and longitude coordinates is to fill in a blank on a paper form. They never try to use the locations after collecting them and are, therefore, unaware of the data quality problems they create for data users. Others see the need for improvement and express their desires for common standards and accurate devices. Some of the surveyors who commented on the study shared comments such as: "Everybody needs to be on the same coordinate system," and "We need uniform GPS usage." Many of the non-surveyors shared similar thoughts on the eventual use of the coordinates they collect: "I want to see the data I collect with the GPS on a map," and "I want to know how to find a project using this information." These thoughts demonstrate a perception that more can be done with GPS and the data collected by them. Other comments also reflected the need for stricter usage procedures and training such as: "I don't know what I can do with GPS; I don't know enough about it," "We sometimes get the latitude and longitude from Google Maps," and "I change latitude and longitude to degrees, minutes, and seconds."

Implementing a comprehensive strategy coupled with better training and equipment will allow DOTD to reach the goal of effective GPS technology use. To realize a high-level of data quality (one that meets or exceeds engineering, operational, and legal standards), the Department must adopt and implement a comprehensive GPS technology management plan.

OBJECTIVE

This study was conducted to analyze the current state of GPS technology and its use within the Department and compare it to the best practices from other organizations using GPS. Researchers needed to discover what types of equipment are being used and what kinds of data are being used to locate and collect. They also needed to know how the locational information was processed and managed once it was collected. All of this was necessary for the ultimate goal, to develop a GPS technology management plan based on best practices. Researchers needed to discover management practices from DOTD, other state and federal agencies, and the GPS industry, then build a plan to guide the Department's use of GPS into the future.

SCOPE

The study was limited to the use of GPS devices to record geographic locations of features necessary to perform the duties of DOTD. The study revealed four different categories of these devices. One category is recreational grade devices. Current uses of recreational grade devices at DOTD are:

1. Outdoor advertising permits
2. Water well permits
3. Driveway permits
4. Utility crossing permits
5. Right of Way (ROW) boring locations
6. Borrow pit locations
7. Railroad crossing inspections
8. Bridge inspection
9. Recording accident locations

Another category of GPS devices is referred to as professional grade or mapping grade devices. Current uses of mapping grade devices at DOTD are:

1. Road inventory
2. Facilities and landscape maintenance
3. Environmental and archaeological studies
4. Levee inspection

Two other types of GPS users fall outside the scope of this project. There are several hundred PDAs (hand-held devices) with cellphone-level GPS capabilities in use at DOTD. They did not fall within the scope of this study because they are part of the Agile Assets system, implemented in 2010. They are not used to collect accurate feature locations or their attributes the way GPS field data collection is defined and practiced in the geospatial community. The professional land surveyors within the Department using survey grade GPS equipment in their work are also outside the scope of this study because their operational methods and standards are already well established and regulated by professional licensing. Field data collection of geographic features falls between these two extremes of GPS usage and is the focus of this study.

METHODOLOGY

Literature Review

The first task of the project was to conduct a literature search of previous and on-going nationwide research projects and case studies on the management of GPS technology. "GPS technology management," for the purpose of the study, was defined as an agency or organization's system for the inventory, maintenance, and support of their GPS devices and users. This definition covers how an organization repairs, updates, controls access to, and trains users in the use of all GPS devices including receivers, antennas, data collectors, and all additional components.

Three strategies were used to find GPS technology management related documents. LTRC provided access to the Transportation Research International Documentation (TRID) database search engine where various searches were conducted using combinations of keywords like "GPS," "management," "standard," "guideline," and "organization." These same keyword combinations were also used in internet searches. Another method was to contact different state DOTs by phone and ask if they have any kind of documentation, guidelines, or studies related to GPS management. The third approach was to contact various representatives of GPS technology vendors.

The literature review via TRID and the internet revealed that there are countless studies, reports, and papers on the various technical aspects of GPS like tropospheric influences on signals and receiver accuracies. While interesting, they did not shed any light on the topic of GPS technology management.

While not nearly equal to the number of technical GPS papers, there were several pertinent documents on GPS standards and user guides for a wide variety of uses and organizations. Their primary concern was the proper use of GPS for that agency's individual needs including proper device settings, operation, and data migration to their databases that will be useful in preparing a set of guidelines at DOTD.

The most applicable documents were from the Texas Commission on Environmental Quality (TCEQ), whose operational policies and procedures define standards and procedures for GPS device settings, data collection and user training/certification. Their certification process requires potential GPS users to pass a GPS test including field data collection, which must be repeated every two years. TCEQ staff members are required to be certified by the commission to collect GPS data.

Survey Design

The study team prepared a survey intended to gauge the use and management of GPS technology within DOTD. In consideration of this goal, the survey was designed with the understanding that there are basically three many-to-many relationships at play between the GPS users, devices, and datasets.

The situation as envisioned has several likely workflow scenarios:

1. One user can use multiple GPS devices to collect data for the same dataset.
2. One user can use the same device to collect data for multiple datasets.
3. Multiple users can use multiple devices to collect data for the same dataset.
4. Multiple users can use the same device to collect data for multiple datasets.
5. Multiple users can use multiple receivers to collect data for multiple enterprise datasets.
6. Spatial data collected from multiple devices can be stored in the Geographic Information System (GIS) and non-GIS datasets.

With this in mind, the survey is designed for each GPS user in DOTD to answer questions divided into four sections:

1. USER - A section of the survey about the user's own training and use of GPS (see Appendix A).

2. GROUP - Another section about the user's workgroup and how they use GPS (see Appendix B).

3. DEVICES - A separate section for each GPS device that the user works with. If he uses three different GPS devices, then he will fill out three of these sections (see Appendix C).

4. DATA - A separate section for each kind of data that the GPS user collects features for. If a user collects features for five different kinds of data with the GPS devices, then he will fill out five separate versions of this section of the survey (see Appendix D).

Simultaneously, a less detailed survey would be sent to agencies outside DOTD with GPS devices to solicit responses regarding their best practices for the management of GPS technology. Information from these surveys as well as interviews with GPS technology

vendors will be compiled to form a comprehensive best practices vision that will be used to create an overall GPS technology management plan for all DOTD.

The Appendix (A – D) contains DOTD GPS user questions in their survey order. Some questions are self-explanatory, while other questions have explanation notes included.

A list of 12 questions was compiled to send to non-DOTD agencies using GPS (see Appendix E). Their focus was on the management of the devices and any training or certification required by those agencies. The finished survey plan was presented in the interim report on May 5, 2011, and reviewed in a meeting in Baton Rouge on May 19, 2011.

Survey Meetings

The surveys were designed to be filled out in a group setting with a member of the study team present to go through the questions and answer any issues that arise. After several emails, contact persons were found for every district office and a schedule of meetings throughout mid-June was set as follows:

- June 7—Chase 8:00 AM, Monroe 2:00 PM
- June 8—Alexandria 2:00 PM
- June 13—Bridge City 8:00 AM, Hammond 2:00 PM
- June 14—Baton Rouge 8:00 AM, Headquarters 2:00 PM
- June 15—Lafayette 8:00 AM, Lake Charles 2:00 PM
- June 20—Bossier City 2:00 PM

At some of the meetings, large groups of PDA users would show up, but it became clear that their involvement in GPS feature gathering was not within the scope of the project. Surveyors would often attend the meetings as well, mostly out of interest. There were several interesting discussions at the meetings regarding the usefulness of GPS for the Department. Kurt Johnson was able to attend about half of the meetings and provided a more official presence to the meetings as well as stimulated and encouraged much of the discussions.

For those individuals who were unable to attend the scheduled meetings, survey questionnaires were distributed via email and their appropriate responses solicited. Not all individuals important to the survey were immediately identified. This became evident after a preliminary review of district responses where one district had completed a particular section of the survey while another district's response was absent. This prompted an inquiry to the district absent of a response to determine if someone was available to respond or if it was

merely an oversight. One such example was when the Bridge City office was surveyed; there was no survey response from anyone listing well inspection as a use for GPS in their job. An inquiry was made and the staff member who performed well inspections was found and provided a survey via email.

Survey Results

The surveys identified four categories of GPS use within DOTD. The first category is PDA users. These are PDA devices with built-in GPS capabilities. Users of these devices use GPS to tie their work activities to logmile-segments within the Agile Assets Management software. It was determined that users of these devices would be excluded from the survey because of the PDA's proprietary use with the Agile Assets software rendering them unavailable for general GPS activities.

The next category identified by the survey (in order of use sophistication) is the recreational-grade GPS users. These individuals are using a device that is specifically designed for recreational activity and considered too inaccurate for most professional applications. Data collected from these devices are primarily to find latitude and longitude coordinates associated with permitting and inspection activities. The data gathered from these devices is discussed in the next section.

The third category of GPS users at DOTD are the mapping-grade GPS users. These users primarily work out of the Baton Rouge headquarters and perform a variety of GPS activities that will be discussed later. It is important to note that many of these mapping-grade devices are functioning but aging.

The last category is the survey-grade users consisting of individuals who hold professional land surveyor licenses and work for DOTD. These are highly accurate GPS devices requiring considerable training and experience to operate. Although professional surveying activities fall outside the scope of this project, DOTD's professional surveyors were generally interested in the study and provided several useful comments and observations while attending the meetings. At many of the district offices, the local surveyor took the initiative to organize and gather other GPS users to participate in this study's survey questionnaire.

Tasks Using Recreational Grade GPS Devices

Several different tasks using recreational-grade GPS were identified at various DOTD districts, these tasks include but are not limited to:

Outdoor Advertising Permits

DOTD has oversight for the placement of billboards and similar outdoor advertisement signage or structures within a set distance of the roadway. Of the signs or billboards that are in question, a recreational GPS is used to collect locational coordinates, which are then hand-written to a permit form, along with a drawing, and submitted for further processing and inclusion in a database. This work is done on site but then added to the computer database later in the office where the permit form is also scanned. A specified or desired accuracy associated with the locational coordinates of these signs were not reported in the surveys.

Water Well Permits

DOTD, in conjunction with the Department of Natural Resources (DNR), has authority over the inspection and permitting of water wells in the state. The coordinates of individual well locations are captured with a recreational GPS receiver and then hand-written on a permit form that is later added to DNR's Strategic Online Resources Information System (SONRIS) database. A desired accuracy of 10 ft. was reported in one survey response for collecting this data.

Driveways Permits

Inherently understandable, DOTD has authority for inspecting and permitting driveways that connect to state roads. The locational coordinates for driveways are captured with the recreational GPS and then hand-written to a permit form. Driveway coordinates are eventually added to a permit database. Accuracy requirements were not reported in survey responses.

ROW Borings

Subgrade soil survey borehole locations are captured on site and transcribed into a spreadsheet for review by geotechnical engineers. Plans are for these to become a GIS dataset in the future. Ten-ft. accuracy specifications are reported in survey responses.

Borrow Pits

Latitude and longitude of borrow pits are captured with the GPS receiver. This work is done on site but then stored in spreadsheet. Ten-ft. accuracy needs are reported in one survey response.

Railroad Crossings

Latitude and longitude of RR crossings are captured with the GPS receiver and hand written on the Crossing Inspection Checklist. Copies of the forms are sent to the highway rail safety engineer. There is currently no database to store the coordinate information.

Bridge Inspection

Latitude and longitude of off-system bridges (beginning and end of structures) are captured with the GPS receiver and handwritten on a master structure form that is later sent to Baton Rouge. Coordinates are also added to the PONTIS database later in the office. Some users believe the data is used by the GIS section for bridge mapping but a highly variable 10 ft. to 100 ft. accuracy was reportedly needed. Some bridge inspectors are even using automotive navigational GPS devices for their coordinates.

Utility Location

All places where utilities (gas, water, or electric) cross state roads are tracked by the Department. The latitude and longitude of utility crossings are captured with the GPS receiver and added to a permit by hand. This work is done on site, but then the information is transcribed into the permit database. No desired accuracy information was given on surveys.

Accident Reports

The Department works in cooperation with the La. Department of Public Safety (DPS) to capture accident locations on state roads. Latitude and longitude of crash locations, especially in case of fatalities, are added to paper accident reports. No desired accuracy information was given on surveys.

Tasks Using Mapping Grade GPS Devices

Road Inventory

The Road Inventory group has three trucks with mounted mapping grade GPS units (Trimble TSC, over 10 years old). They drive all the roads in state and collect road information such as road width and type while also collecting locations for other points of interest like fire stations and schools. Newly built roads are sought out (sometimes with difficulty) and added to the inventory. They use Trimble software to edit the data (removing GPS anomalies) and post-process the data. The data is then downloaded to a server for the Cartography unit to add to their roads dataset in ArcSDE. The GPS survey reported that six ft. accuracy was needed for this dataset. They also want easier-to-read screens like those found on modern tablet style devices.

Facilities and Landscape Maintenance

The Facilities and Landscape Maintenance group use Trimble XP and GPS Analyst to create shapefiles of trees and driveways but stated that there is currently no database setup for this

task. They specifically requested training and stated that they output to shapefiles but did not specify a use for them. No data accuracy information was reported.

Environmental and Archeological Sites

Department personnel are using a Trimble GeoXT to collect environmental, wetlands, noise, and cultural resource data for use in ArcGIS. Users check out geographic layer to the GeoXT with GPS Analyst and use Skyplot to plan their trip before going out. The group has written their own data collection instructions. Their archeological data collection follows the Louisiana Division of Archaeology Standard for field survey. They also adhere to the Corps of Engineers required accuracy for wetland data when collecting wetland features. When they purchased their GPS receiver, they were sure to purchase a unit that met those specifications. When done with their field work, they use Microsoft ActiveSync to download data from the GPS unit in its cradle then use the software GPS Correct for post processing before storing their data in a GIS Database. They reported a need for one meter accuracy in the GPS survey along with a desire for a unit with photo capabilities.

Levee Inspection

The public works section is using Trimble Yuma's for levee inspections. They were delivered as part of an ongoing project to develop levee inspection software for DOTD. The contractor who is developing the system made the selection primarily because they have both an integrated GPS and camera (which they are using), and they also run Windows 7 instead of a mobile Windows version. Department personnel are driving the levees to map the centerline and marking fences, ramps, slides, and washouts.

Outside Agency Surveys

For comparison and to discover best practices for GPS technology management within the "spatial community" (the realm of GPS/GIS practitioners), a smaller survey was prepared and sent to a variety of public and private organization using GPS. Their responses give a picture of how they are managing and implementing GPS technology.

Types of GPS Devices

Responses indicated that nearly all mapping work is done using mapping grade GPS receivers. Where recreational grade units were used for mapping, they are now being phased out because they are unfit for that purpose. Recreational receivers are used in multi-tiered strategies where surveyors with survey grade equipment do all the most detailed mapping for engineering plans and cadastral applications. Mapping grade receivers are used for GIS related mapping of point, line, and area features and their attribute collection. Recreational

grade receivers are occasionally used for locating features where locational accuracy is not a high priority and there are no locations or attributes to collect. The overall level of satisfaction with their use of GPS is very high.

GPS Management

The size of management strategies vary with the scale of GPS implementation and use within the organizations that develop them. Smaller agencies have evolved very basic systems for maintenance and control where GPS units are basically under the care of the main user. There is no system to control access to the equipment other than arranging to obtain GPS from the person who has it. Some larger agencies have developed more sophisticated systems involving a check-out/check-in system, but those seem to happen in cases where there are several GPS users sharing very few GPS units or the units are only used occasionally.

Oversight of GPS technology in all types of organizations was typically performed by the GIS group (sometimes called the GIS/GPS group). Roles and job titles often include references to GPS within these groups when there is significant reliance on GPS in the organization. When the need arises, a single GPS manager role is created or appended to a GIS manager's job duties.

For larger agencies with a diverse GPS user community, GPS oversight committees are formed to provide executive guidance to the cooperative GPS effort. Such committees coordinate efforts in procurement, use and data standards, support, and GPS policy for their organizations. Committees are typically composed of members from each GPS user segment within the agency.

Standards

There is also great variance in the development of data standards and data collection standards, which tend to reflect the size and nature of the organization's GIS/GPS usage. Smaller agencies working on a project-by-project basis are not as dependent on standards as larger agencies with many people in different locations are creating data that will eventually reside in a common enterprise database. Standards definitions are most often the product of GPS/GIS data managers and often in conjunction with GPS/GIS oversight committees and IT data managers.

GPS data standards emerge as a product of the work flows (permitting or inspections) and their related GIS databases. GPS units have data attribute menus and pick-lists built from the database definitions of the data standards. Accuracy needs of the data determine how the locations will be collected in the field including which device to use, settings on that device, and post processing of that data.

GPS data collection standards include permissible GPS variables like Position Dilution of Precision (PDOP), number of satellites, and mask. The eventual precision needs of the data will determine what acceptable collection standards for each individual data type are and what type of equipment can be employed in collecting it.

Training

Most of the smaller agencies surveyed listed their GPS vendor training as their preferred method. Usually a two-day class about overall GPS usage was deemed sufficient without customized classes. Vendors typically teach courses in their own offices or at client sites and have a variety of classes related to GIS or surveyor type GPS work. However, when generic vendor GPS training is taken, there is still a need to instruct new users in the organization's GPS standards, data structures, and field practices. Only the largest users were developing their own custom GPS classes with their own trainers.

GPS Technology Industry Discussions

Another source of information was discussions with representative from the GPS vendors. They were:

Jason Hooten, GIS Sales Manager, Topcon Positioning Systems, Inc.
Gretchen Hartley, Regional Sales Manager US SE – Mapping and GIS division, Trimble Navigation Limited
Rayward Chung, APAC Sales Manager – Mapping and GIS, Trimble Navigation New Zealand Limited
Michael W. Harvey, Product Marketing Manager, Leica Geosystems
John Florio, Senior Sales Manager, Juniper Systems
Eric Bock, Technical Support Specialist, Navigation Electronics, Inc. (NEI)

From an industry perspective, the vendors haven't seen wide scale adoption of comprehensive GPS technology management plans because small organizations do not perceive a need for them or lack the resources for their development, and several of the larger organizations just haven't addressed that need yet (but need to). It is generally agreed that, overall, GPS technology management within large organizations hasn't received the attention it deserves and they welcome this study with interest.

One practice that GPS vendors have developed to address this issue for their clients is the creation of hosted management Web sites that allow organizations to register and inventory their equipment. GPS vendors can also use that data to send notifications about available updates for the customer's equipment and add their own information when maintenance or repairs are done to the units. While not a complete solution in itself, these secure GPS

management sites would be a great tool for a GPS manager to track all the different variations of receivers and their software configurations. The Web sites even have scaled access where a GPS user can see all the information about his GPS unit, and a GPS coordinator/manager can see information about all the GPS units within that agency.

Vendors also said that most large organizations have a main GPS coordinator that oversees all things GPS and is a main point of contact for the GPS vendors. Creating a GPS committee is also very common in larger organizations. Better GPS technical management by their customers was seen as a benefit to vendors who will have an easier time supporting and training their customers.

Texas Examples

Texas Department of Transportation

One example of a managed approach to GPS implementation is the Texas Department of Transportation. Under their IT - Technical Services Division, they have a Surveying, GPS & GIS branch. For GPS, they have a "Mapping Grade Team" of three people that manage their GPS applications. Their role is to research the latest changes in technology and devices along with proper GPS procedures and present the latest information on the subject to the Department. They also do all GPS support and training for TxDOT. Their training lasts 2.5 days and covers topics from GPS basics to current TxDOT policy. They are currently creating their Standard Operating Procedures (SOP) documents covering how to collect field GPS data and "take it all the way to GIS." The SOPs are created and updated by the development team in response to TxDOT's decisions about field data needs.

An illustration of the Mapping Grade Team's work is their application for driveway permitting. They developed GPS standards, applications, and procedures for the driveway permitting task by approaching it with a "what are they trying to accomplish" question and built their solution around that. Users can now follow those procedures and use their applications for permitting work with GPS devices.

For purchases, the divisions within TxDOT all pay for their own equipment with the IT department's approval of the purchases to make sure that the devices meet the set standard.

Texas Commission on Environmental Quality

Another example is the Texas Commission on Environmental Quality (TCEQ). All GPS users in the commission purchase GPS units from their own budgets but adhere to TCEQ guidelines in the agencies Operational Policies and Procedures (OPP) found at: http://www.tceq.texas.gov/assets/public/permitting/watersupply/pdw/swap/opp0812.pdf

(see Appendix F). This ensures that all GPS purchases have the required capabilities. All OPP content is the product of the GPS Committee which defined settings, standards, and procedures.

To collect GPS data at the TCEQ, a user must first be trained and certified. TCEQ has its own classes and trainers that teach the entire GPS process from properly capturing points to downloading features in a GIS. There is one GPS coordinator defined by the OPP whose responsibilities include tracking certified users, approving trainers, and coordinating GPS activities with other state agencies.

Software licenses like Pathfinder Office are controlled by the IT section because it is software on a PC. The Terrasync, ArcGIS Mobile, and ArcPad licenses are purchased on an individual basis.

18-Hour Recreational Grade Receiver Test

The latitude and longitude values in Table 1 were recorded over an 18-hour period from the exact same location at two-hour intervals using a Garmin eTrex recreational grade GPS unit. The values were mapped in ArcGIS in a WGS84 datum. The map in Figure 1 demonstrates that recreational grade units can return coordinates for one location (the larger circle) that are over a hundred feet from each other (readings six and eight are identical). If GPS-collected data for wells, signs, bridges, and railroad crossings etc. are ever to be used with other geographic datasets and within a GIS environment, recreational grade GPS receivers are simply not accurate enough for these features to align in any meaningful way.

Table 1

Latitude and longitude coordinates from recreational grade GPS receiver at one location

Reading Number	Latitude North	Longitude West
1	30° 01’ 12.5”	95° 27’ 36.4”
2	30° 01’ 12.7”	95° 27’ 36.4”
3	30° 01’ 12.5”	95° 27’ 36.3”
4	30° 01’ 12.9”	95° 27’ 36.0”
5	30° 01’ 12.5”	95° 27’ 36.5”
6	30° 01’ 12.9”	95° 27’ 36.4”
7	30° 01’ 13.1”	95° 27’ 36.8”
8	30° 01’ 12.9”	95° 27’ 36.4”
9	30° 01’ 12.7”	95° 27’ 36.2”
10	30° 01’ 13.0”	95° 27’ 36.6”

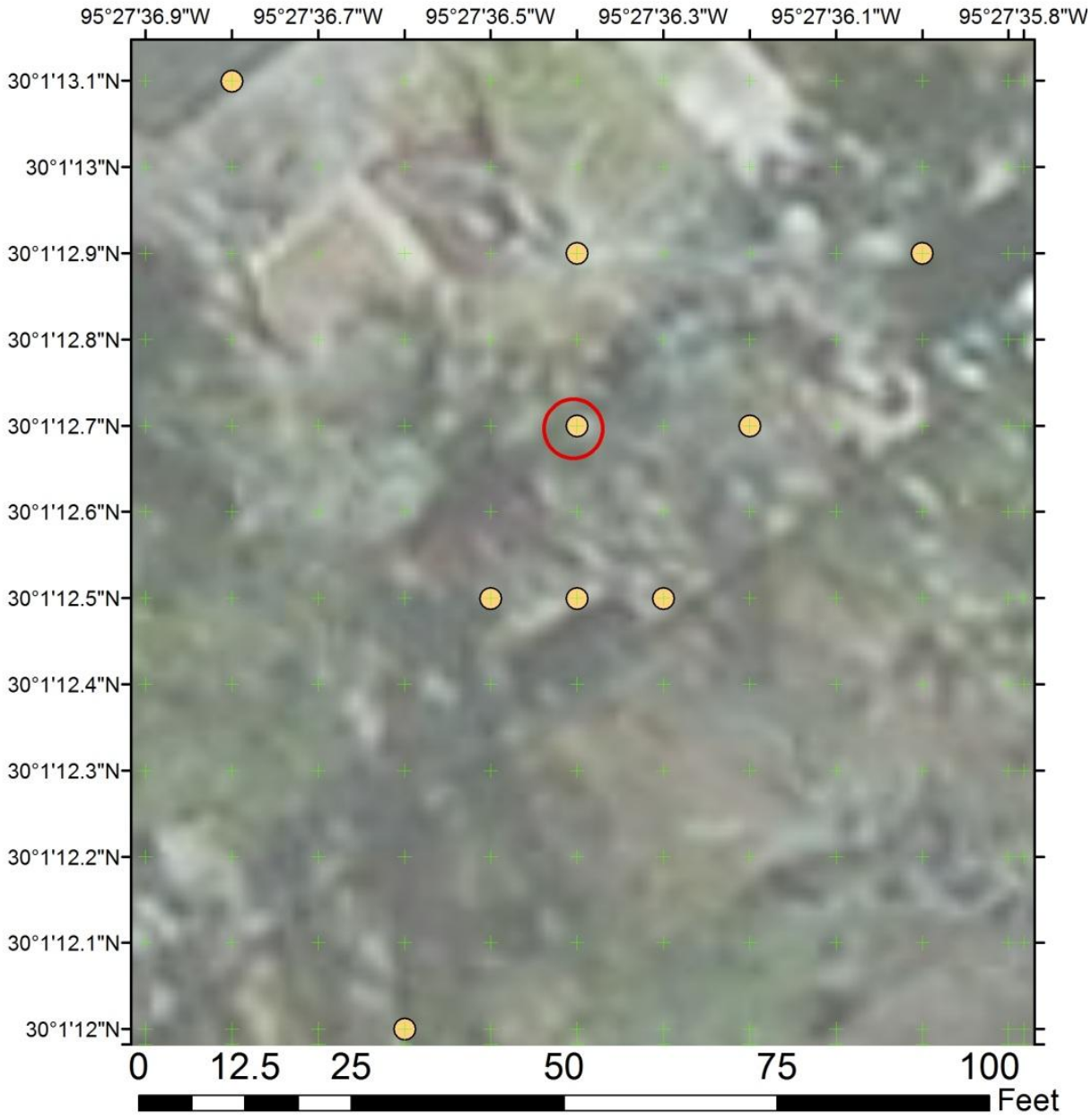

Figure 1
GPS test coordinate results

DISCUSSION OF RESULTS

Within the Department, there is widespread use of recreational-grade GPS receivers. In developing a plan for the future use of GPS, a determination must be made whether recreational-grade units meet the requisite locational accuracy capabilities of DOTD, or should mapping-grade receivers be used for all data collection.

Thirteen uses of GPS have been identified within the Department with nine of those tasks currently being performed using recreational-grade units. In analyzing the benefits of a mapping-grade standard for data collection versus the current blend of mapping and recreational-grade technologies, the issue reduces to whether the data being collected require the greater accuracy of mapping-grade GPS. Accuracy issues have appeared throughout this report. The paradox seems to be that many DOTD employees are content with the simplicity of the current system they use, but not aware that the inexpensive hardware produces low-accuracy data that cannot be used by the Department for engineers and mapping applications once collected.

If the locational information is never to be used then there is no reason to invest in mapping grade units. On the other hand, if it will be used, it must be accurate enough to be useful for the purpose it is collected as well as in subsequent geospatial analyses. Locations captured from recreational-grade GPS receivers are not accurate enough to support geospatial analysis.

Based upon the data collected in this study, a clear high-level picture was taking shape of how DOTD could best manage its GPS technology. Best practices for DOTD could be stated as:

1. Better quality GPS devices in the hands of the users. Mapping grade devices are accurate, have post-processing capabilities, and attribute collection schemes. Photographic and laser ranging capabilities are options as well.

2. A well-managed data management approach. Standard procedures that provide a mechanism for field collected data to be processed, stored, and retrieved in a GIS. The mechanism will have a plan for uniform post-processing of GPS data.

3. An overall GPS organization approach. Develop DOTD policies and procedures that create and empower an oversight committee that addresses the needs of all GPS data collection and supports the data quality necessary to use GPS data for subsequent geospatial analyses. This includes procedures, accuracy standards, and database

schemas to be guided by the committee. A GPS coordinator will enforce, update, and coordinate the policies and procedures and lead in GPS device maintenance.

4. A mandatory training curriculum for the use and maintenance of GPS technology. This curriculum will be required for all DOTD personnel before they use GPS. It will include information on the PPM governing GPS, all current DOTD GPS standards, and any other pertinent information, established by the GPS coordinator and the oversight committee.

CONCLUSIONS

The proposed plan is to migrate DOTD's use of GPS technology to mapping grade standards and establish an oversight, support, and training system. The following GPS technology management plan is proposed. These should be for the foundation for the development of an official DOTD Policy and Procedures Manual section.

1. Establish a mapping-grade GPS oversight committee for DOTD that can direct the evolution of GPS technology adoption in a manner that benefits the entire Department in a comprehensive way. Operational standards, database schemas, changes in equipment, and proper field methods for the Department's wide use in GPS data collection will be stipulated.

2. Create a primary GPS contact within each district office and DOTD sections using GPS. These individuals will serve on the oversight committee. Their role will be to act as the GPS lead, in their unit, for user questions and equipment coordination between users at each district office.

3. Acquire high-end mapping-grade GPS receivers for each district office and section using GPS. A receiver with the following features will form the standard for DOTD GPS devices:

    - Advanced ambiguity solutions
    - Built-in camera
    - Long-life battery
    - Laser range-finder

    These features will form the foundation for all GPS field data collection for many years. The built-in camera can make data collection more useful for subsequent data users. The laser range-finder would increase efficiency and promote safety for Department personnel, allowing them to collect features from a safe distance (especially along busy highways). A range-finder would also allow data collectors to stand in a location with good satellite reception and still accurately locate features in poor locations (such as under tree canopies or structures).
4. Create standard data schemas for all GPS collected data that facilitate flow easily into GIS. Create data collection menu systems for the GPS units that adhere to this schema. Also build in accuracy standards for the data collection system. For example, if a PDOP is too high, the unit will not allow data collection.

5. Establish a central GPS coordinator, at DOTD Headquarters, that will post-process all GPS datasets when they are sent in by users. This person will then import the data into a GIS database. The coordinator will be responsible for the general inventory (possibly using a vendor-based inventory management system) and oversight of all units staying abreast of maintenance and upgrade issues. The coordinator will also be responsible for ensuring that all users are trained before collecting data.

6. Create training classes (within the Department in conjunction with LTRC) that teach the basics of GPS and how to properly use the technology, hardware, and software. Training should include topics such as how to import the data into the appropriate database, DOTD GPS standards, and the PPM governing the use of GPS technology. Successful completion of the training should be required before DOTD staff and contractors are allowed to use GPS devices to perform work for the Department.

7. Create a web-based mapping system for all GPS datasets so data collectors can see their results in a GIS. Quickly allow users to see their collected points and attribute data and even make edits.

8. Ensure that all GPS devices have uniform setup, menus, and capabilities for ease in training and interoperability. Units should be interchangeable within the Department and, consequently, more useful in emergency response.

RECOMMENDATIONS

1. Upon adoption of this plan, form the GPS oversight committee and add members. Membership should include representatives from districts and sections across the Department. The committee members from the districts will serve as the main GPS contacts within each district. Members should have a background and experience in mapping or surveying, and be a GPS user with experience using the technology.

2. Establish a GPS coordinator position, and select a person not serving on the committee to fill this position. The coordinator will work with the committee to create database standards for the GPS units, which will include schemas for data uniformity.

3. Have the committee and GPS coordinator create a proposal for the purchase of GPS units with precise standards based on the management plan and agreed upon user needs. These units should have attribute collection capabilities and advanced ambiguity solutions for sub meter accuracy. Buying the units at once should provide a bulk cost savings. There should be enough units purchased to cover the immediate needs of the Department. These will be distributed appropriately to ensure universal access to GPS technology across the Department.

4. Obtain and test GPS units. Tests will include all components, accuracy of each unit, data collection, onboard mapping software, and data connections with the IT network. Methods will be established for post processing data using available CORS data.

5. Create and test menu systems for data collection based upon defined data collection requirements.

6. Create training classes that teach the basic concepts of GPS, how to properly use the units, and how to incorporate data into target database.

7. Train users in the proper use of the new GPS devices.

8. Deliver devices to the designated custodians in each district and section.

9. Encourage and promote the adoption of GPS technology by providing users with access to training and webinars and by mentoring the use of GPS Department wide.

A potential roadblock to success is the lack of funding for purchasing the first standard GPS units. If the entire set of hardware and software cannot be procured, purchasing a smaller set of devices will still allow for the GPS management plan to be developed and evolve to a

point when other units can be brought online. The GPS plan, as defined herein, with its standardized data schema should facilitate capacity expansion to meet Departmental needs.

Establishing the GPS coordinator position is essential to the success of this plan. This may not require the employment of a new individual using a new authorized position and could be fulfilled by existing staff. However, the duties of this position will be new to DOTD and will require new time, not currently accounted for within the DOTD workforce.

Several activities are necessary for a successful implementation. First, the GPS Oversight Committee must form and make the overall plan known to the Department, especially, the current GPS user community. They have the responsibility to explain to everyone the need to upgrade equipment and how this will save time and increase data quality.

Another necessary activity is to alter the current permit and form a system to allow for records created from the GPS to be added to the database. The current process of transcribing hand written coordinates to a paper form from an inaccurate GPS receiver has several opportunities to generate inaccuracies. Automating the collection with GPS data collectors will eliminate many of the potential error entry points.

It is essential to demonstrate to DOTD administration and upper management the benefit to adopting the policies and procedures produced by this plan. The new standards will produce a higher quality of data faster, more accurate, more thorough, and much safer for employees. It will also provide more reliable data to decision makers in the future. Accurate locations of bridges, railroad crossings, and other data can be useful innumerous ways, if properly collected.

Executive support for any proposed modification in employee workflows has historically proven to be a predictor of employee acceptance. It must be proclaimed to all involved that adoption of mapping-grade or “professional grade” GPS receivers will make their work safer and more accurate, but will also provide a foundation for many potential uses in the future.

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

CORS	Continuously Operating Reference Station
ft.	foot (feet)
GIS	Geographic Information System
GPS	Global Positioning System
DOTD	Louisiana Department of Transportation and Development
DNR	Department of Natural Resources
DPS	Department of Public Safety
LTRC	Louisiana Transportation Research Center
OPP	Operational Policies and Procedures
PDOP	Position Dilution of Precision
PPM	Policies and Procedure Manual
ROW	Right Of Way
SONRIS	Strategic Online Natural Resources Information System
SOP	Standard Operating Procedures
TRID	Transportation Research International Documentation
TCEQ	Texas Commission on Environmental Quality
TxDOT	Texas Department of Transportation

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APPENDIX

Appendix A LADOTD GPS User Survey Questions
Appendix B LADOTD GPS User Group Survey Questions
Appendix C LADOTD Device Survey Questions
Appendix D LADOTD Data Survey Questions
Appendix E Non-LADOTD Agency Survey Questions
Appendix F TCEQ GPS Operational Policies and Procedures
Appendix G Tabulated Survey Results
Appendix H LADOTD GPS Technology Management Plan

APPENDIX A

DOTD GPS User Survey Questions

Personal Information:

Name:	**Email:**
Section:	**Group:**
Phone:	

Identifies each user, contact information, and position within the department

TRAINING:

1 Describe how were you trained to use the GPS devices (class, self, coworker, book)?

Not a multiple choice question. User describes GPS learning experience.

2 When were you trained?

To determine how long ago the user was trained.

3 How long was the training?

To get a sense of the scope of the training.

4 What was the cost of the training?

If charged a fee from an outside training outfit. Help in determining overall GPS cost to Dept.

5 Did you receive any certification from your training?

To see if the training also certified the user as skilled in operating GPS by taking a test. Not the same as a certificate of completion just for taking the class.

6 Have you had any updates to your training since then?

Further insight into training needs.

7 Does your group have any GPS devices that you have not been trained to operate?

See if there are any units that may be utilized if a user was trained. Also shows if any devices going to waste.

8 Have you been instructed on your group's GPS data standards?

Yes, No, I don't know of any standards are all possible answers. Hopefully the answer is yes here but and answer of "what standards?" is important to know also.

9 Have you been instructed on your group's GPS data collection procedures?

Tells if there are known procedures.

10 Would you say that you understand Horizontal and Vertical datums?

If you don't know what these terms mean then the answer is no. It will be important to let users know that this is not a job evaluation but a survey to see what must happen for them to better use the technology. Of course, they may "think" they know when they really don't.

USE:

11 Are you confident that you are properly using the GPS device?

It is understood that confidence does not equal real skills but if there is a lack of confidence, that is a real problem also.

12 What software do you normally use to download GPS data (EX: ESRI's GPS Analyst, Trimble's Pathfinder Office, Leica's Data Pro)?

We might have to tell the users to jot some things down in the invitation to the meeting so they will have answers ready. It would be better than "I don't know" in answer after answer. This question is simply to see what the user uses most of the time.

13 How many different GPS devices do you use?

Just asking for a number here.

14 How often do you use a GPS device to collect data?

Frequency of use question, "once a week," "twice a month," "every day"

15 Are you able to return to a GPS location again in the field using the GPS?

Are you skilled enough with the GPS unit to navigate back to a point using the GPS device?

16 Are you registered for support with a vendor's help system like "Trimble Assistant"?

Need to know the extent of people going to vendor help sources.

DEVICES:

17 Are you skilled at changing the settings or menus of the GPS device?

Some users may not know what they are for or don't know how to alter them.

18 Do you change the settings on the GPS device?

Many people said that they never touch the settings on their devices.

19 If so, how often do you change the settings and why?

Some users change them for various reasons.

APPENDIX B

DOTD GPS User Group Survey Questions

Personal Information:

Name:

Section: **Group:**

DEVICES:

1 Are there any other GPS devices that your group has that are not being used? If so, please describe the type, year, how you got them, and why they aren't being used.

There have been reports of unused devices that need to be identified.

Explain why they are there.

2 Are there any non-working devices in your group? If so, what plans do you have for them?

There may be broken devices that just got left there.

See the groups intentions for the devices.

3 Does your group share GPS devices with any other groups?

Helps to identify and model usage.

4 Is there a GPS device, capability, or application that you wish your group had?

Some users may be aware of a better GPS option for their work.

5 Does your group also collect GPS locations from cell phones or recreational grade GPS devices?

See if they are using cell phones or car navigation units, hopefully not.

6 Does your group have a subscription to use GulfNet?

Need to assess the current use of GulfNet within the Dept.

7 If so, what type of license or user agreement do you have?

We also need to know what their arrangement is with C4G.

MANAGEMENT:

8 Does your group have someone "in charge" of all your groups GPS equipment? If so, who?

See if there is any management duties assigned formally or informally. Name that person.

9 Do you have a schedule set up for device maintenance and upgrades?

See their level of management.

10 Who do you take the GPS devices to for repairs?

Another level of management question.

11 Who does your group call for help with the devices?

Want to see who users are going to for service.

12 Who keeps the GPS devices maintained for your group?

Not the same as repairs. Want to know who their main help contact is.

13 Does your group have a centralized storage system for your GPS devices?

We need to see how the groups are already storing what they have.

14 Does your group keep track of who-has-what GPS device at any given time?

Level of management of devices.

15 Does your group have a budget or plan for GPS device maintenance and replacement?

Another management question to see if forward thinking and control.

APPENDIX C

DOTD Device Survey Questions

Fill out one survey per GPS device.

Personal Information:

Name:	**Group:**

GPS DEVICE SPECIFICS:

1 What is the name of this GPS device (how do you identify this particular device)?

How do you tell this device apart from other devices, what do you call it? "Dave's GPS" is OK.

2 What is the make and model of this GPS device?

They might need to bring their devices along to answer some of these.

3 What is the device's operating system (windows mobile)?

Self-explanatory.

4 Does the device have an augmentation signal receiver?

Yes, no, I don't know, I wish it did.

5 Does this device use WAAS?

Some devices are able to receive WAAS and some aren't. Do they already use it or know what it is?

6 Does this device use Gulfnet?

Yes, no, I don't know, I wish it did.

7 What is the device's battery life?

Self-explanatory.

8 Does the device have a bar code reader?

Yes, no, I don't know, I wish it did.

9 Does the device have a laser range finder?

Yes, no, I don't know, I wish it did.

10 Does the device have a camera?

Yes, no, I don't know, I wish it did.

11 Does the device have the ability to collect data other than latitude & longitude?

Yes, no, I don't know, I wish it did.

12 Does the device have note taking capabilities?

Yes, no, I don't know, I wish it did.

13 Is the device "ruggedized" (all weather), or does it need to be?

Yes, no, I don't know, I wish our last one was.

14 What output file formats does it make (ssf, dbf, shapefile, text file)?

Interested in what formats they have access to and which one they use the most.

15 Is this GPS device fast enough for you?

If the user thinks the device is slow there is a temptation to alter the settings or not wait long enough during data collection.

16 How confident are you that your GPS locations are accurate enough?

We want to know the users confidence in their use of the equipment.

17 What software does it have for data collection (EX: ESRI's ArcPad, Trimble's Terrasync)?

Self-explanatory.

18 Is it permanently mounted to a piece of machinery, an ATV, or to a car or truck?

Need to know how many of these devices are mounted to something else and how many are hand held.

PROCURMENT:

19 What year was it purchased?

Self-explanatory.

20 What did it cost?

Self-explanatory.

21 For what kind of data collection was the GPS purchased?

What purpose did they have in mind when they bought the GPS unit.

22 Is this GPS device leased or owned?

Self-explanatory.

23 What is the device's expected life span from when you first received it?

How long does the user think the unit should last.

24 Was there a warranty when the device was purchased?

Self-explanatory.

25 If so, is it still under warranty?

Self-explanatory.

MAINTENANCE:

26 Has this GPS device been reliable?

Yes or no. Explanation if answer is no.

27 Have you had any problems with this device?

Similar to previous question but allows users to give a "yes, but" answer.

28 Have you had to replace any parts?

Self-explanatory.

29 Have you had to get it repaired?

Self-explanatory.

30 Where is this device kept?

Helps understand the use and management of the device.

31 Has the device been upgraded with later versions of software or operating systems?

We will, of course, explain this when we are going through the survey.

32 If so, who upgraded it and when?

Hopefully there is someone on top of this stuff.

33 Does the device have all the cables, batteries, and other equipment that you need?

Yes, no, I don't know.

USE:

34 What is the GPS device's setting for PDOP?

Self-explanatory.

35 What is the GPS device's setting for # of Satellites?

Self-explanatory.

36 What is the GPS device's setting for epochs?

Self-explanatory.

37 What is the GPS device's setting for elevation mask?

Self-explanatory.

38 What is the GPS device's setting for signal strength?

Self-explanatory.

39 How and why were these settings chosen and by whom?

Self-explanatory.

40 Do you use trip (mission) planning software before you collect data?

Yes, no, I don't know, what is that?

41 Do you store GPS collected data in a GIS dataset, non-GIS database, or both?

The Lat & Long values can be loaded into a GIS, but they can also be used as plain LL values in a database table or spreadsheet.

APPENDIX D

DOTD Data Survey Questions

Fill out one survey per GPS device.

DATASET:

1 What is the name of this GPS collected data set?

Need the name of the feature class that is created from GPS devices.

2 Please describe this data set.

A brief description of the data including how it fits into the overall work of the Department.

3 What kind of accuracy do you need when collecting this data?

Want to know users perception of just how accurate their coordinated have to be (15 ft, 1 meter, 1 foot).

4 Do you collect GPS data using a custom application like "Wet Collect"?

I'm guessing that most aren't but we need to inventory them just in case they are.

5 Do you do real-time differential correction or post processing for this data?
If so, please describe.

Hopefully everyone knows what this is and what is done about it.

6 Does your data collected have to meet any other guidelines or standards
(EX: FEMA, Corps of Engineers, US Dept. of Transportation, FEMA)?

Self-explanatory.

7 Do users store metadata or mission field logs with GPS data?

Do they keep metadata or notes about the collection mission?

8 What kind of QA/QC process do you use?

Self-explanatory.

9 Where is data being used (in the GPS software, loaded into a database, loaded into GIS [which GIS software])?

Describe the use of the data in terms of your LADOTD job description.

10 How do you correct data errors when they are discovered?

Do you collect metadata for the data set when you collect it?

DATA COLLECTION:

11 Which GPS device(s) do you use to collect this data (give names from the DEVICE survey)?

Which devices names earlier in DEVICES portion does each user use to collect this data.

12 Do you use a mission checklist during GPS collection?

A checklist to be sure that they are properly following procedures throughout GPS collection. Procedures can be different from one dataset to the next.

13 Do you upload any data to the GPS unit before a mission?

Background images or datasets.

14 How do you know if the data collected is accurate or meets any accuracy standards set by LADOTD?

Do they know of any standards for a dataset and how to check if data collected accurately.

15 Do you output in GIS features or waypoints?

Could be different for each user and each dataset.

16 What feature formats do you use (ssf, dbf, shapefile, text file, handwritten)?

In what format are the locations being collected on the device.

17 How do you transfer the data from the GPS device (piece of paper, exported/downloaded Via wire, wireless device, email)?

Describe the download process.

18 What do you do for data quality control for this data set?

What steps do they take to be sure that the data is as accurate as necessary.

19 Do you collect Z values?

Collecting vertical measurements with their Lat and Long.

20 Are you able to see a map of your data on your GPS data collector while still in the field?

See if they can do field QA/QC.

21 Do you use any kind of "field data collection checklist" when you collect GPS data?

Any set rules or guidelines for the actual collection phase of a mission.

APPENDIX E

Non-DOTD Agency Survey Questions

1 Please summarize what types of GPS devices your department uses.

A good response will have a small inventory of devices and counts.

2 Are you satisfied with the performance of this equipment? Please explain.

Seeking a description of their satisfaction, not just a yes or no.

3 Do you have a standard GPS technology management plan? Please describe.

Seeking a description of their plan, not just a yes or no.

4 What section in your agency manages your GPS devices?

IT support, GPS support, or somebody else.

5 Please describe your system of access control (check-out / check-in) to the devices?

Seeking a description of their system.

6 Who does your agency call upon for GPS maintenance, repairs, and upgrades?

Could be an internal help-desk or an outside vendor.

7 For what kinds of tasks does your agency use GPS?

The main purpose of all their GPS data collection.

8 What kind of data is collected with the equipment?

Rivers, pipelines, roadways?

9 Does your agency use any 3rd party software in the data collection process?

Off the shelf or customized applications?

10 Does your agency have a GPS data collection guideline, manual, or standard to be followed by GPS users? Can it be made available for this study?

Self-explanatory.

11 Please describe your policy for accuracy and precision in GPS data collection?

Focusing on their perception and control of accuracy and precision.

12 Please describe the GPS training for your users and is there a certification process?

Not certificate of completion but tested in use of equipment certification.

APPENDIX F

TCEQ GPS Operational Policies and Procedures

CHAPTER 8 INFORMATION RESOURCES
Texas Commission on Environmental Quality

8.12.01 GLOBAL POSITIONING SYSTEM: Policy Introduction

PURPOSE

To establish the policy and procedures for the Texas Commission on Environmental Quality (TCEQ) relating to the collection and management of positional data under its jurisdiction including, but not limited to, facilities, assessment sites, and incident sites, using Global Positioning System (GPS) technology.

To inform management, supervisory personnel, and employees of the need to establish accurate and consistent procedures for data collection using GPS across all program areas, and of the benefit of an agency-wide approach to the use of GPS technology.

To provide standards for procurement of GPS hardware and software, training and certification of staff that use GPS, GPS data collection procedures, and data elements to ensure agency-wide standards for acquisition and management of positional data obtained using GPS technology.

To provide oversight responsibility for this policy through the TCEQ GIS Steering Committee and an employee designated to perform GPS coordination duties for the agency.

POLICY

The TCEQ will use GPS technology in conjunction with other positioning technologies to collect and maintain accurate positional data. The agency will create and maintain the highest level of programmatic data accuracy and consistency in conformance with these minimum policy standards to support internal and state-wide geo-positioning efforts.

DEFINITIONS

Datum - A mathematical model used by cartographers to define the shape of the earth in a specific area. Mapping applications in the United States are normally based on either the North American Datum of 1927 (NAD27) or the newer, more accurate North

American Datum of 1983 (NAD 83). The coordinates of a given point depend on which datum is used.

Differential Correction - A process applied to raw GPS data that removes certain types of error; primarily, the error introduced by Selective Availability. This process requires correction data from a reference GPS receiver operating from a precisely know location. The process can be performed in "real time" if the reference receiver broadcasts the correction data and if the user can receive the correction data.

GIS - Geographic Information System. A collection of hardware, software, data, and procedures to collect, store, manage, query, and analyze spatial data as well as traditional tabular data. Computer mapping is a part of GIS, but beyond that, GIS adds a spatial dimension to all types of geography-based tabular data, allowing new, powerful tools for data integration, query, and analysis in a wide variety of applications.

GPS - Global Positioning System. A satellite-based system managed by the Department of Defense to allow absolute geographic position measurement worldwide.

CHAPTER 8 INFORMATION RESOURCES

Texas Commission on Environmental Quality

GPS Data, Raw - Positional data obtained by a GPS receiver before errors due to Selective Availability have been removed. These positions are typically only accurate to 100 meters.

GPS Data, Corrected - Positional data obtained by a gps receiver that has been differentially corrected to remove certain types of error, primarily Selective Availability. These positions are considered accurate to within 12 meters or even one meter, depending on equipment and procedures used.

Metadata - Metadata is "data about data." In the case of positional data, the data stored in a database will include not only the latitude and longitude of a location, but also additional data elements that describe how and when the position was measured, and an assessment of the accuracy of the measurement. These additional data elements are called metadata.

Minimum Elevation - A GPS processing parameter that determines how high in the sky a satellite must be in order for the receiver to accept data from it for calculating a position. Measured in degrees of arc starting at the horizon.

PDOP - Positional Dilution of Precision. A measure of the quality of a GPS measurement taken from a given set of four satellites at a given time. If the satellites are not widely distributed from the user's location, the PDOP value will be higher, and the quality of the measurement will be diminished. PDOP values over 6 are generally not acceptable.

SA - A procedure used by the Department of Defense to limit the positional accuracy available to non U.S. military users of GPS. Errors introduced by SA can be effectively removed through differential correction techniques.

AUTHORITY
TCEQ Commissioners

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8.12.02 GLOBAL POSITIONING SYSTEM: Guidelines and Information

GPS COORDINATION

Steering Committee Role. The TCEQ Geographic Information Systems (GIS) Steering Committee consists of one voting representative from each Division that utilizes (or is beginning to utilize) GIS technologies and related technologies such as GPS. This committee will be responsible for implementing and managing this policy.

Coordinator Role. Certain aspects of GPS coordination are best handled by a single responsible individual. The executive director may reassign this responsibility at any time.

The responsibilities of the GPS coordinator will include:

- Obtaining Agency GPS certification, if s/he has not already done so
- Maintaining a database of all agency personnel who have been certified to collect GPS data.
- Approving certain agency personnel to serve as certification trainers.
- Providing assistance to the program areas in writing specifications for GPS hardware and software purchase, and in establishing efficient, cost effective GPS data collection procedures that meet the requirements of this policy.
- Fostering communications within the GPS user community in the agency to promote problem solving, sharing of useful techniques, and resource sharing.
- Coordinating with other state agencies and the Texas GIS Planning Council to ensure consistency with related external data collection efforts and compliance with emerging State-wide GPS standards.
- Keeping the GIS Steering Committee informed of any issues relating to the agency's GPS Policy or important developments in the GPS field.

GPS TRAINING & CERTIFICATION

To ensure that the agency receives reliable and accurate positional data, all agency personnel and contractors that will collect positions with GPS must first be certified.

An agency GPS certification program will serve to:

- Make appropriate GPS training easily available.

- Ensure that staff training is sufficient to cover GPS techniques normally used within the agency.
- Identify each certified individual with a certificate number.
- Provide reasonable validation that the accuracy of positional data obtained through GPS meets the Agency's GIS Positional Data Policy.

Trainer Qualification. The GPS certification trainer must be recognized by the GPS coordinator as being qualified to give GPS certification training. The trainer is not necessarily an agency employee. If the trainer is an agency employee, s/he must:

- Be currently certified.
- Be approved to perform GPS training by his/her section manager or division director.
- Have actual field GPS data collection experience.
- Agree to include the minimum class elements as listed next.

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- Be familiar with the logistical aspects of conducting a certification class (this normally involves having recently served as an assistant to another trainer).
- If the trainer is not an agency employee, s/he must:
    - Have experience in GPS field data collection and GPS training.
    - Provide information to show that the proposed class includes the minimum elements described below, including discussion of relevant agency operating policies.

GPS Training. Personnel will qualify for GPS certification through successful completion of a training class that includes certain minimum elements, as identified in the following paragraphs. Minimum lecture and/or demonstration elements include:

- Background of the Global Positioning System
- GPS accuracy issues
- Relevant agency operating policies
- Operation of GPS equipment, including basic troubleshooting
- Data collection procedures
- Differential correction, both real time processing and post processing
- Coordinate averaging for point locations
- Data output in formats appropriate for import to GIS or tabular databases

Minimum hands-on exercises, to be successfully completed by each student, include:

- Pre-planning, including data quality objectives, equipment and materials needed, logistics of field data collection, and prediction of GPS data collection conditions
- Navigation to a given coordinate
- Storing and transferring raw positional data
- Differential correction of raw data through post processing
- Averaging corrected point data and outputting to a GIS file

Class exercises shall also include computer plotting of point data to allow students to better understand GPS accuracy issues and the effects of differential correction and point data averaging.

Equipment for GPS Training. The student and his/her division are responsible for providing appropriate GPS equipment required for certification training. Although each student is encouraged to use their own unit during the class exercises, the trainer may approve sharing of units, no more than two students to one unit. In the event that units are shared, it is essential that each student directly performs each of the exercise steps at least once.

Contractor Certification. A person contracted to collect GPS data for the agency is also required to obtain certification. This can be obtained in any of three ways: completing an agency training class, completing a suitable training class offered by an outside vendor, or by providing documentation of sufficient GPS expertise and experience. Contractors must agree to adhere to relevant agency policies when collecting GPS data.

Certificate Numbers. After each certification class, the trainer will report the names of those who successfully completed the class, and the date of completion, to the GPS coordinator. The coordinator will assign certificate numbers, add the names and numbers to the certification database, and print certificates for distribution by the trainer.

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Maintaining Certification Status. The coordinator will monitor staff usage of GPS approximately two years after certification to determine if the employee will need refresher training in order to maintain certification status.

GPS DATA ACCURACY CERTIFICATION

The current Geographic Information Systems Positional Data Policy sets a Root Mean Square (RMS) horizontal accuracy of 25 meters. GPS positions obtained by certified personnel, using appropriate equipment (as specified below), and appropriate data collection standards (as specified below), properly documented (as specified below) will be certified under this policy as meeting the 25 meter horizontal accuracy standard.

Offset Measurement. It is sometimes impossible, or impractical, to place a GPS receiver immediately on top of or adjacent to the site being positioned. In this case, it is appropriate to obtain a GPS position at a nearby point with a known offset (X/Y or Bearing/Range) from the site. In these cases, potential error associated with the offset

measurement must be added to the potential error associated with the GPS measurement in order to assess the accuracy of the site position.

Accuracy Level. A Program Area may impose higher accuracy requirements for certain purposes, as appropriate. It is the division's responsibility to develop the proper procedures, including training for specialized techniques such as offset measurements, to ensure that the division's required accuracy level is obtained. In the event that a position is needed that cannot meet the 25 meter accuracy standard, the position will not be considered certified, and the lower accuracy level will be reflected in the associated metadata.

GPS EQUIPMENT STANDARDS

Many models of GPS receivers and accessories are available from a number of manufacturers. These receivers differ greatly in accuracy and features; some are incapable of making measurements that meet the agency's horizontal accuracy standard. To ensure that the agency can get maximum benefit from its investment, the following minimum specifications will apply to all GPS equipment procurements:

GPS Receiver. A GPS receiver can be either a standalone unit, or a GPS module plugged into a portable computer. The GPS receiver must:

- Have six channel parallel reception or better.
- Employ these processing parameters:
    - Position acquisition rate - 1/second or better
    - Position mode - 3D (uses 4 satellites)
    - Maximum PDOP - 6 (or less)
    - Minimum Elevation - User-selectable*

**The elevation mask requirement may be waived if the division can show that post-processing differential correction will never be needed on raw data obtained by the receiver.*

- Have the ability to perform real-time differential correction.
- Have the ability to store at least 180 raw position measurements for the purpose of post processing differential correction. *(This requirement may be waived if the Division can show that it will never need to perform post-processing differential correction on raw data obtained by the receiver.)*

- Have the ability to transfer almanac and position data to a personal computer via a serial port.
- Include software to perform mission planning, differential correction, point data averaging, and conversion to common formats.
- Have a water and shock resistant case.
- Include portable power source(s), which will last a full working day.

Real-time Correction Receiver. This may be a standalone unit, or it may be integrated within the GPS receiver. The real-time correction receiver must:

- Receive correction data from a recognized, reliable source, and which is appropriate for real-time correction in the geographic area in which the GPS measurements will be made.
- Output correction data in RTCM-SC-104 (Radio Technical Commission of Maritime Service - Special Committee Paper No. 104) format via an RS-232 cable, which matches the GPS receiver.
- Include portable power source(s), which will last a full working day.

GPS DATA COLLECTION STANDARDS

Detailed data collection procedures will be developed at the division level and will be in accordance to this policy. Divisions are strongly encouraged to utilize real-time differential correction techniques whenever possible, to reduce staff time and to eliminate the possibility that an error may occur during post-processing differential correction. The division's procedures should take into the account the possible need for post-processing differential correction in the event that real-time correction fails due to signal loss.

- When using real-time correction, the correction data must be obtained from a recognized, reliable source, as determined by the GPS coordinator.
- A single position reading obtained through appropriate use of real-time correction will be certified under this policy as meeting the 25-meter horizontal accuracy standard. However, in the interest of obtaining better accuracy for little cost (about two minutes of staff time), staff is encouraged to average 100 or more positions to arrive at a final measured position.
- When using post-processing correction to measure a point location, staff must store at least 180 uncorrected positions in a file. Correction data must be

obtained from a recognized, reliable source (such as the reference network maintained by the Texas Department of Transportation), as determined by the GPS coordinator. The corrected positions should be averaged to produce a final measured position.

- All GPS measurements should be taken using a set of four satellites that are in a favorable configuration. The Positional Dilution of Precision (PDOP) is a recognized method to quantify how well the satellites are configured. The GPS receiver must be set to not record positions during times that the PDOP exceeds a value of 6.

MINIMUM DATA ELEMENTS

The Geographic Information Systems Positional Data Policy charges the GIS Steering Committee with implementing a minimum set of common data elements for positional data. All site positions measured with GPS and stored in an agency database or spreadsheet file will include, at a minimum, the following data elements:

- Latitude – in decimal degrees, using NAD83 datum

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- Longitude – in decimal degrees, using NAD83 datum
- Method of Collection – using standard EPA codes
- Date of Collection – date the GPS measurement was taken
- Horizontal Accuracy Assessment – value in meters
- GPS Certificate Number – to identify who made the measurement

Data Dictionary. The Steering Committee will produce a data dictionary to aid in implementing these data elements in all databases that receive GPS positions.

Geographic Identification Number. An additional data element, called a Geographic Identification Number, is required under the GIS Positional Data Policy when positions are entered into a Geographic Information System.

APPENDIX G

Tabulated Survey Results

	Dist	Name	GPS Device	Uses	Frequency
1	02	Richard Baudier	Lowerance	accidents	1 / month
2	02	Scott Rowe	Lowerance	accidents	4 / month
3	02	Mark Andras	Magellan Merid	bridge inspection	1 / month
4	02	Donna Painter	Lowerance	railroad crossings	1 / month
5	02	Herbert Conners	Magellan Merid	water wells	1 / month
6	04	Rhonda Foster	Garmin III	water wells	3 / week
7	05	Nathan Monroe	eTrex	railroad crossings	1 / month
8	05	Ricky Gross	eTrex	railroad crossings	2 / month
9	05	Newell Dalton	eTrex	RR Xng, accidents	2 / month
10	05	Ryan McMillan	eTrek	water wells	3 / week
11	07	Darrell DeVille	eTrek	borrow pits, borings	5 / year
12	07	Steven Young	eTrex	bridge inspection	1 / month
13	07	Roger Moses	eTrek	driveway permits	1 / year
14	07	Derek Dominique	eTrek	soil surveys	1 / year
15	08	Jason Roerk	eTrex	bridge inspection	5 / year
16	08	Danny Howard	eTrex	driveway permits	5 / week
17	08	Shelia Terrell	Garmin 60CSX	driveway, outdoor ad	3 / week
18	08	Gary Eldridge	Yuma	levee inspection	weekly
19	08	Grady Cross	Yuma	levee inspection	daily
20	08	Rick Cozby	Trimble	permits, utilities	5 / year
21	08	Huey Lipsey	Garmin 60CSX	permits, utilities	daily
22	58	David Dupree	Trimble GeoXM	outdoor advertising	5 / year
23	61	Joshua Stutes	eTrex	water wells	1 / year
24	62	Vincent Caleagno	eTrek	bridge inspection	5 / year
25	62	Michael Bentivegna	eTrek	bridge inspection	5 / year
26	62	Grant Berne	Garmin Xtrain	water wells	daily
27	62	Jarrett Lambert	Garmin 12	water wells	1 / year
28	HQ	Steven Sibley	Garmin 750	bridge inspection	1 / month
29	HQ	Staci Palmer	Trimble GeoXT	environmental	1 / month

30	HQ	Kevin Mannie	Trimble GeoXT	environmental	4 / month
31	HQ	Chad Turner	Trimble GeoXT	environmental	4 / month
32	HQ	Andy Sanders	Trimble	facilities	1 / month
33	HQ	Herb Piller	Trimble	facilities, driveway	1 / month
34	HQ	Delicia Justice	TrimbleXP	road inventory	daily
35	HQ	Larry Burch	Trimble TSC1	road inventory, RR Xng	daily

APPENDIX H

LADOTD GPS Technology Management Plan

LADOTD
GPS Technology Management Plan

LTRC 11-2P

Inner Corridor Technologies, Inc.
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10/13/2011

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Overview

Over many years, GPS technology has been adopted by different sections within DOTD, with no uniform standards for accuracy, operation, hardware, or software. As a result, it is unknown who is using GPS, which makes and models are being used, and for what purposes. This study assesses the current state of GPS within the Department and compares it with current best practices, as defined by other large agencies and the GPS industry. Surveys and interviews of GPS users at DOTD, other organizations, and vendors of GPS technology are utilized to determine best practices with which to formulate management concepts for GPS technology use at DOTD.

The goal of the management plan is to guide the Department's use of GPS technology into the future, based on best practices. The plan proposes at least one high quality GPS receiver at each district office and others to support GPS use for all sections across the Department. Additional equipment are proposed, such as laser range finders to facilitate GPS data collection where safety or overhead interferences are a concern.

The plan also proposes GPS management through the implementation of a GPS technology coordinating committee (GTCC) within DOTD, comprised of GPS users and GPS technology support staff. The committee will drive the overall vision of GPS usage and set standards for data, operating procedures, coordinate accuracy, and training. The plan also calls for the establishment of a GPS coordinator to be responsible for implementing GPS technology standards and policies. This can be created either as a new position or a modification to an existing position. The coordinator will also maintain an inventory of GPS technology and will be responsible for device maintenance and upgrades. These are new job functions within the Department and are essential elements to the success of this plan.

Introduction

Many sections within the Louisiana Department of Transportation and Development (DOTD) are using Global Positioning System (GPS) technology to collect data as a regular part of their work. Currently, there are no established standards or guidelines for the use or management of GPS technology. Therefore, DOTD and the Louisiana Transportation Research Center (LTRC) commissioned Inner Corridor Technologies, Inc. to execute the study entitled *Development of DOTD GPS Technology Management Plan* (LTRC 11-2P).

The objective of the study was to develop a GPS technology management plan, based on best practices, providing standards for GPS use, management, and training for the Department. Management practices of DOTD, other state and federal agencies, and the GPS industry were reviewed to identify "best practices" for GPS technology use. These findings are incorporated into a proposed GPS technology management plan.

The study begins with a comprehensive assessment of current GPS use within the Department, utilizing surveys and meetings with GPS users. Surveys were taken at every district office and Headquarters, in order to build an overall view of the scope of GPS usage and management practices. These were compared with GPS management strategies of other, non-DOTD, organizations with similar GPS usage, as well as, recommendations from the GPS industry. For more information on the study, please refer to the report, *DOTD GPS Technology Management Plan* (LTRC 11-2P) from the Louisiana Transportation Research Center.

Analysis and recommendations are based on the principle that GPS is used as an on-site data gathering tool that collects field data, including geographic location, that flow into mission-specific databases in DOTD. Therefore, like other data, data collected using GPS technology, must adhere to all DOTD data management practices and accuracy standards.

Survey of GPS Usage- Scope and Purpose

This study surveyed the use of GPS technology, Department wide. However, it does not include the use of GPS by the DOTD Location and Survey Section or the use of GPS within the Maintenance Section, involved with the implementation of the Agile Asset system. These were excluded because of their focused work for specific purposes, with identified standards. The Location and Survey Section has a long history of GPS use, employing professional surveying standards and protocols. Agile is a newly implemented asset and maintenance management system, with canned, out-of-the box hardware and software that claims to integrate GPS data collection into a single seamless system.

The purpose for surveying current GPS users was to identify how GPS is used and managed by personnel whose use is incidental to the job they perform. That is employees that use GPS but have no academic or professional background or training in its use. Among this group of employees, two categories of GPS users were discovered. The largest group consists of employees using "recreational grade" GPS devices to perform their work. The second, smaller group employs "mapping grade" equipment in their work. To complete the picture at DOTD, the Location and Survey Section uses "survey grade" technology, and the Agile Asset system is based on "recreational grade" equipment.

Recreational Grade GPS Usage

Recreational grade devices consist of low-cost, store-bought units capable of displaying basic navigational information and displaying data points. These devices are typically unable to capture attributes along with geographic features or use any form of post-processing or real-time correction. The latter two functions are required to calibrate accuracy. Furthermore, recreational grade devices do not allow users to modify or manipulate the receiver's internal settings or report measures of accuracy, such as PDOP (a measure of satellite availability related to coordinate accuracy).

Coordinate accuracy associated with these kinds of devices are usually ±25 feet, with selective availability turned off (best-case scenario), but can vary greatly depending on numerous other conditions (satellite availability, PDOP, *etc.*). The same location collected at different times on the same day can vary by 50 or more feet because recreational grade devices do not have the appropriate hardware and software to correct and adjust for varying ambient conditions. This means a location's coordinates can be collected but navigating back to that same location cannot be done with any certainty.

Recreational GPS use is primarily found in the district offices, where navigation devices are primarily used, and not used as GPS-enabled data collection devices. Very little of the locational information they collect are used as data and entered into a DOTD databases as part of the official record. Instead, location coordinate data, if required, are used to complete a document form such as a permit. These forms are typically paper-type and filled out in the field by hand. When personnel return from the field, the form's information is entered into the computer system and the paper form is digitally scanned into DOTD's document management system. Overall, district personnel who performed these duties were generally unaware and uninformed about how the data they collected are used, stored, or retrieved. This is evidence of a lack of continuity regarding GPS use at DOTD. There is no connection between GPS training, setup, and data collection. Most DOTD employees are not aware of how or why the data are collected much less how it is stored, managed, retrieved, or used to accomplish the Department's work.

The most common recreational device identified in the study was the Garmin eTrex, with a retail price of approximately $100. Other recreational GPS mentioned were the Garmin III, Magellan Meridian, and Lowrance ifinder. All are low-cost, low-accuracy GPS devices never intended by their manufacturers for professional-level infrastructure or asset mapping.

Work Activities Currently Performed Using Recreational Grade GPS

Survey results identify multiple job functions where district personnel use recreational grade GPS in their work. In each of these duties, a single coordinate is collected to mark the location of a target feature. Personnel using these devices like their simplicity, but did not know or measure its associated accuracy. Despite being completely unaware of the poor accuracy of their system, they often noted that their GPS was, "Good enough for what I have to do." From the surveys, it was evident that accuracy was often confused with precision and that most DOTD employees confused the number of decimal places with coordinate accuracy.

The following is a list of DOTD activities that the survey identified as using recreational grade GPS:

> **Outdoor Advertising Permits.** DOTD has oversight of billboards and similar outdoor advertisement that lies within a specified proximity of highways. Recreational GPS devices are used to collect each sign's location, which are then hand-written on a permit form along with a sketch of the sign's location and proximity to the highway. Despite the requirement in federal statutes to maintain specific distance from the highway, there is no documentation of calibration or accuracy for GPS measurements to fulfill this federal responsibility.

Water Well Permits. DOTD, in conjunction with the Louisiana Department of Natural Resources (DNR), has authority over the permitting and inspection of water wells in the state. As part of this authority, individual well locations are captured using a recreational grade GPS, with the coordinates entered on a paper permit form, by hand. The form's information is later added to DNR's Strategic Online Resources Information System (SONRIS) database. A desired accuracy of 10 feet for collecting this data was reported in one survey. There is no accuracy assessment reported with the data.

Driveway Permits. DOTD has the authority to permit and inspect driveways along state roads. Each driveway's coordinates are captured using a recreational grade GPS and then handwritten on a paper permit form. Driveway coordinates are eventually added to a permit database. Accuracy requirements were not reported in survey responses.

Right-of-Way Borings. Soil borehole locations, along transportation right-of-ways (ROW) are captured using a recreational grade GPS. Coordinates of the boreholes are transcribed onto a spreadsheet and then delivered to geotechnical engineers for review. Future plans are to develop borehole locations into a GIS database for easy access and geographic query. Ten-foot accuracy specifications were reported in the survey responses. However, accuracy is not specified or reported with the data collected in the field.

Borrow Pits. Locations of soil borrow pits are captured using a recreational grade GPS. Pit coordinates are then entered and stored in a spreadsheet. A 10-foot accuracy requirement was reported in one survey response. However, no assessment of accuracy is collected or reported with the data.

Railroad Crossings. Railroad crossing locations are another activity where recreational grade GPS are used. The crossing locations are captured and then handwritten on the paper Crossing Inspection Checklist. Copies of the forms are sent to the highway rail safety engineer for review and documentation.

Bridge Inspection. Location coordinates, where the bridge structure begins and ends, of off-system bridges, are collected using a recreational grade GPS. These coordinates are then transcribed to a paper master structure form and later entered into the PONTIS database. Survey responses indicate the GPS data is collected and used for bridge mapping in the DOTD enterprise GIS Data Warehouse. Responses also indicate a wide

range of required accuracy and that some bridge inspectors were using GPS devices intended for automobile navigational to collect bridge coordinates.

Utility Location. DOTD is responsible for permitting all locations where utilities (gas, water, and electric) cross over, under, or run along the side of state roads. The coordinates of utility crossings are captured using a recreational GPS and transcribed to a paper permit form. No required accuracy information was determined from the surveys.

Accident Reports. DOTD works in cooperation with the Department of Public Safety and LSU to identify and locate accident locations on state roads. Coordinates of crash locations, especially in case of fatalities, are collected using a recreational grade GPS and then transcribed to the paper accident report. Reporting accuracies were not specified on the surveys. However, DOTD staff and contractors spend a great deal of time and resources correcting these data prior to analysis and reporting to fulfill federal requirements.

Mapping Grade GPS Usage

Mapping grade GPS devices are much more sophisticated, both in hardware and software, than recreational grade GPS devices and provide many advanced features intended for the precise location of features managed in a professional environment. The following uses of GPS were identified through survey responses and meetings with sections at DOTD Headquarters:

Work Activities Currently Performed Using Mapping Grade GPS

Road Inventory. The Road Inventory group has three trucks equipped with mapping grade GPS units (Trimble TSC, over 10 years old) mounted on them. They drive state roads and collect road information, such as road width and type, while also collecting locations for other points of interest like fire stations and schools. Newly built roads are sought out and added to the inventory. They use Trimble software to edit the data (removing GPS anomalies) and post-process the data. The data are then uploaded to a

server for the Cartography Unit to add to the DOTD roads database. The GPS survey reported that six-foot accuracy is needed for this purpose.

Facilities and Landscape Maintenance. The Facilities and Landscape Maintenance group has used a Trimble XP to locate and identify vegetation and transportation features at DOTD facilities for purposes of maintenance and required facility modifications. Current use of the GPS is limited due to the age of the equipment, availability of firmware updates, and compatibility to other more recent releases of software. Accuracy specifications are not reported.

Environmental Assessment and Archeological Sites. Personnel of the Environmental Section at DOTD use a Trimble GeoXT to collect various types of information related to environmental, wetland, noise, and cultural resources. These data are then uploaded, displayed, and analyzed using GIS tools and applications. Prior to a field collection trip, personnel compile pertinent geographic data layers and upload them to the GeoXT GPS device to be used, in the field, as background reference layers. Trimble's GPS Analyst software extension for ArcGIS is used to perform this task to help determine the optimum date and time for data collection by calculating satellite availability and position in Trimble's "Skyplot" application. Recognizing the need for consistency, section personnel have developed a written procedure, specific to their data collection needs. They also adhere to established guidelines set forth by organizations such as the Louisiana Division of Archaeology and US Army Corps of Engineers. Following a data collection trip, the data are downloaded and post processed. By using Trimble's GPS Correct software, they improve the quality and accuracy of the data. The data are then stored on a common computer within the section. Reported accuracies indicate a need for one-meter accuracy for most applications. Personnel also indicated that an integrated camera within the GPS device is desirable for both safety and efficiency purposes.

Levee Inspection. DOTD's Public Works Section is performing a state-wide levee inspection program to assess and document the condition of levees protecting both human life and property. To perform this task, they purchased Trimble Yuma GPS devices. The Yuma GPS devices were purchased as part of the levee protection project that was organized, developed, and implemented through a contractor. The Yuma device is a tablet style GPS, capable of using MicroSoft Windows 7, with integrated network capability for real–time GPS correction functionality; there is also an integrated

camera for documentation purposes. Personnel report this style of GPS device, along with ESRI's Mobile GIS software, provides an accurate and efficient means for collecting levee related data and utilizing it in a GIS environment.

GPS Management Plan

Based upon the best practices observed from other government agencies and GPS industry leaders, the following GPS technology management plan is proposed.

The proposed plan implements a series of steps that will help guide and migrate GPS technology at DOTD toward a professional-level of mapping grade equipment. This will require standards complimented with structured oversight, support, and a staff training regime. These elements must be incorporated into the formulation of an official DOTD Policy and Procedures Manual section. The following are a set of steps towards establishing a GPS Management Plan:

1. Establish a DOTD GPS Coordinating Committee that can direct the use of Department-wide GPS technology in a comprehensive way. Operational standards, data schemas, appropriate types of equipment, and proper field collection methods will be stipulated by this body.

The Coordinating Committee will have the authority to establish operational standards and field collection methods appropriate for the various uses of GPS technology at DOTD. This includes the development of standardized configurations of equipment that address the wide range of tasks and requirements, while providing the flexibility and accuracy of specific applications. Standards will ensure consistent and accurate data results across the Department. Data schemas, designed and developed according to the task will serve as a template for data collection, avoiding occurrences of missing data and the need for repetitive field work. The committee's oversight of equipment means that the committee will have the authority to define the standard equipment configuration for GPS units across the Department. These standards can be modified as technology and requirements change. The committee must remain abreast of the varied uses of GPS within the Department and choose units that meet all Departmental needs.

2. Create a primary GPS contact at each of the district offices, as well as, those sections at DOTD that use GPS to perform their work. These individuals will serve as members on the Coordination Committee and represent the various needs and concerns of their respective

workplace. These individuals are expected to be advanced GPS users who can also serve as a GPS advocate and provide technical support in their workplace. Each district GPS lead will be responsible for equipment maintenance and upgrades as well as scheduling equipment use. To perform this role, GPS leads must be knowledgeable in all facets of GPS technology, including operation, collection, processing, and integration into DOTD databases and GIS.

3. Acquire professional, mapping grade GPS receivers, as well as related peripheral equipment for each district office and section using GPS technology. GPS receiver specifications should include but not limited to:

- Advanced ambiguity solutions
- Network capability for real-time processing
- Sunlight-optimized display
- Extensive data dictionary capabilities
- Built-in camera
- Long-life or swappable battery
- Rugged design
- Other equipment – laser range finder

4. Develop standardized data schemas for all data collected using GPS technology. This will facilitate the use and compatibility of GPS collected data into a GIS.

5. Develop and publish guidelines for parameter settings, related to specific tasks, for GPS operation and collection. Inherent in these settings will be threshold values such as number of available satellites or collected readings per feature to facilitate accuracy and uniformity of the collected data. It is the committee's responsibility to ensure standards meet all the data collection requirements of GPS users at DOTD.

6. Establish a central GPS coordinator at DOTD. The coordinator will be responsible for the general inventory and oversight of all units staying abreast of maintenance and upgrade issues. The coordinator will also be responsible for ensuring that all users are trained before collecting data.

The GPS coordinator will be the focal point of all GPS use at DOTD. This position will be called upon when non-standard GPS uses are required like shifting equipment between locations in response to repairs or emergencies.

7. Develop a structured GPS technology training program, in conjunction with LTRC, to teach the fundamentals and principles of GPS technology, through advanced data collection, processing, and GIS analysis. Training should be specific to DOTD's established GPS standards, as well as the PPM governing the use of GPS technology. Successful completion of training, and possible certification, should be required before DOTD staff and contractors can perform GPS-related activities for the Department.

8. Establish an approach for GPS technology that is consistent, uniform, and interoperable throughout the entire Department. This allows for equipment to be easily shared, familiar to all users, and consistent in results. This capability is especially important for rapid deployment or emergency response is critical.

Implementation Plan

1. Upon adoption of the GPS Technology Management Plan, the GPS Oversight Committee should be formed and members appointed. Committee members will be comprised of representatives from each of the district offices and sections utilizing GPS technology across the Department. Members should have knowledge and technical experience in mapping or surveying and be a user of GPS technology. The committee will be responsible for the execution of the remaining implementation steps.

2. A GPS coordinator position represents new responsibilities at DOTD. It should be established as either a new position within the Department or assigned to an existing position, recognizing that the duties of this position will replace or expand that person's current job. The coordinator will work with the members of the Coordinating Committee to develop GPS data standards for the Department. The coordinator will manage all remaining implementation steps, working in cooperation with the Coordinating Committee.

3. The Coordinating Committee and GPS coordinator will research and identify appropriate types of GPS equipment that meet the demands of the Department. A proposal and purchase solicitation will then be developed and issued to prospective vendors for equipment. Capabilities of selected GPS equipment should include specifications listed previously in the GPS Management Plan section, item 3.

4. Train users in the proper use of the new GPS devices. All purchased devices will be used in comprehensive "roll-out" training before the devices are distributed.

5. Deliver devices to the designated custodians in each district and section.

6. Encourage and promote the adoption of GPS technology by providing users with access to training and webinars, and by mentoring the use of GPS, department wide. The GPS Coordinating Committee and the GPS coordinator will take the lead in a continuing educational effort to promote the increased data accuracy, ease of collection, increased productivity, and safe-use of the GPS devices.

Benefits

Benefits of adopting the GPS Management Plan are realized in cost savings, improved data quality, more efficient data collection, safety improvements, and reduced legal liability. Examples of these benefits appear below:

1. Financial Savings. At one meeting, it was stated that some DOTD employees were manually moving GPS points using GIS, relocating them from their collected locations to the highway lines. This is a highly labor intensive process and a great waste of resources. If that person were making $20/hr. and spent 2 hours a week making these changes that would equal $2,000 a year. The improved data collection and accuracy would pay for the GPS device within 3 years.

2. Improved Safety. If an employee in the field collecting data was able to use a laser range finder to collect locations on or near highways and dangerous locations, that person would be able to stay in a safe location and collect the data much faster. Having to mark location in and around highway traffic was the most frequently mentioned safety concern of the GPS users surveyed.

3. Data Accuracy and Reduced Legal Liability. Accurately collecting features like utility permits, water wells, and driveways will reduce the likelihood of legal liability from mis-located features.

Summary

The current condition of GPS usage at the Department has only a few sections using mapping grade GPS receivers and sound methodologies. Several others employ inappropriate recreational grade devices for collecting coordinates, mainly for the purpose of filing a portion of a paper permit form. There is no mechanism to manage the devices or ensure the proper use of the devices.

The proposed plan will create a coordination body with the authority to specify uniform data collection and management practices for GPS usage and data flow. Also proposed is the purchase of a sufficient number of mapping grade GPS units that will ensure that field data collection is faster, more accurate, more thorough, and much safer for employees.

Finally, the new policies and procedures will produce accurate data that is used, today, by the data collectors as well as users in the future who need data of documented quality to use for purposes not yet anticipated.