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FINAL REPORT

GTI PROJECT NUMBER 20735 and 20656

GPS-Based Excavation Encroachment Notification

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Table of Contents

Table of Figures

Page

Table of Tables

Page

Executive Summary

Excavation damage is the primary threat to the integrity of the natural gas distribution system. According to the Common Ground Alliance, the two primary root causes of excavation damage are failure to notify the one-call center and careless excavation near utility lines. The objective of this project was to develop and demonstrate a GPS-based system that monitors excavation activity. The system provides a warning if excavation activity is occurring outside of a valid one-call ticket or in close proximity to underground facilities.

The system developed in this project builds upon technology deployed in earlier pilot projects lead by the Virginia one-call center. The Phase I pilot project developed technology that allowed the boundary of one-call tickets to be identified in the field using a GPS-enabled mobile phone. The Phase II project developed a system that allows facility locators to use GPS-enabled locating devices to capture the coordinates of underground facilities during routine one-call locates. This project, Phase III, adds excavation location monitoring technology to provide a system that provides a real-time warning of excavation encroachment.

A combination of off-the-shelf, modified, and new technology was used to develop the Phase III system. A digging trigger was developed to ensure that the system only reports excavation location information when digging is actually occurring. Commercially available asset tracking equipment was customized to monitor the location of excavators with GPS. Commercially available GPS-enabled locating equipment was used to capture the location of underground facilities during routine locates. A portal was developed to collect data on the location of one-call tickets, excavation activity, and underground facilities. An on-board software system for excavation equipment was also developed that provides a real-time warning to excavators based on the asset location data collected with the GPS-enabled locators.

The developed technology was tested and implemented in a series of demonstrations with stakeholders in Virginia. The results of the project proved the concept and value of excavation location monitoring and real-time warning to excavators. Additional technology refinement and further implementation and pilot projects are recommended to support the adoption of excavation monitoring technology. Implementation Guidelines for further deployment are provided.

Introduction

In the United States critical infrastructure is often buried underground. This includes over 2.3 million miles of oil and natural gas transmission and distribution pipelines. It also includes millions of miles of telecommunications networks, electric power distribution systems, water and sewer systems and other utilities that provide vital services.

Underground facilities are vulnerable to damage that can result during excavation activities. Excavation is defined as any operation using non-mechanical or mechanical equipment or explosives in the movement of earth, rock or other material below existing grade. Thousands of excavations occur daily within the United States.

Damage to underground facilities can result in serious consequences to both public safety and the environment and cost millions of dollars each year to both the public and private sectors. Table 1 shows the impact of excavation damages to energy pipeline systems (hazardous liquid and natural gas) nationwide from 2002 through 2010 using data from the Pipeline and Hazardous Material Safety Administration (PHMSA) Incident Database[1].

Table 1. Pipeline Incidents Resulting From Excavation Damage

Reporting Year	Number of Incidents	Fatalities	Property Damage
2002	258	12	$119M
2003	298	12	$157M
2004	312	23	$305M
2005	338	13	$1,424M
2006	256	19	$149M
2007	269	15	$145M
2008	279	9	$542M
2009	272	13	$167M
2010	255	22	$985M

Based on data from the Common Ground Alliance (CGA)[2], the two leading root causes of excavation damage are failure to notify the one-call center prior to excavation and insufficient excavation practices (careless digging near underground facilities).

Effective damage prevention programs are necessary to ensure public health and safety, environmental protection, and continuity of vital services. The premise that underlies all effective damage prevention programs is that damage prevention is a responsibility shared among all stakeholders.

Key to the effectiveness of damage prevention programs is communication among stakeholders in the exchange of accurate and timely information about planned excavations and the underground facilities that may be affected by those excavations. To help prevent excavation

1 PHMSA Significant Incident Files. http://primis.phmsa.dot.gov/comm/reports/safety/sigpsi.html
2 CGA's DIRT Report for 2010.
http://www.commongroundalliance.com/Template.cfm?Section=DIRT_Overview&CONTENTID=6875&TEMPLATE=/ContentManagement/ContentDisplay.cfm

damage, information about planned excavations should be communicated to the underground facility owners/operators that have facilities in the area of each excavation before digging begins. This allows facility operators to determine if they have underground facilities in the excavation area that could be damaged. Facility operators can then locate and visibly mark their facilities so that the excavator can dig with care around them.

However, visible marks are sometimes not enough to prevent excavation damage. Markings can disappear or become less obvious especially in a busy construction site. Excavators can become distracted and not see the markings. In some circumstances, excavators may choose to ignore the markings and dig carelessly around underground facilities. Additionally, excavators may dig outside of a valid ticket area where facilities have not been identified and marked.

To address the two primary root causes of excavation damage, GTI has developed and demonstrated the effectiveness of linking GPS technology with excavation activities and one-call centers in a program aimed at enhancing pipeline safety by synchronizing the locations of one-call tickets, underground facilities and excavation activity. The technology addresses the temporal and passive nature of markings by providing the ability to alert excavation operators when they encroach upon pipelines and other facilities, or if excavation is taking place outside of a valid one-call ticket area.

This project built on technology developed and implemented in the Virginia GPS Pilot Program described below. Phase I and II of the program are described below and were led by the Virginia Utility Protection Services (VUPS). Phase III (this project) was led by GTI with support from VUPS and several other stakeholders in Virginia.

Phase I – Electronic Whitelining

Phase I of the Virginia GPS Pilot Program developed technology, processes, and procedures to demonstrate the feasibility of using GPS-enabled cell phones and other portable devices to create a “whiteline” polygon representing the boundary of the one-call ticket based on the GPS coordinates of the phone that called in the ticket. The system reduces the volume of each ticket volume to the precise area where digging will occur. The system was successfully implemented in one county in Virginia with VUPS, several excavation contractors, and other stakeholders.

Phase II – Electronic Manifest

Phase II demonstrated the feasibility of using GPS-enabled locators to create digital maps of all locates performed during the execution of a one-call ticket response. The digital map of the underground facilities in the one-call ticket area has been termed “Electronic Manifest”. Data collected with the GPS-enabled locator is transferred to the one-call center, utility company, and excavator and can be viewed with a variety of formats. Phase II technology was successfully demonstrated in an extended pilot project and is still in use by several utility companies.

Phase III – GPS Based Excavation Encroachment Notification

Phase III (the subject project) developed and demonstrated a system that utilizes GPS technology to monitor the location of excavation activity and provide an encroachment warning. The data collected with Phase I (GPS coordinates of one-call tickets) and Phase II (GPS coordinates of underground facilities) technology was used to identify excavation activity taking place outside of a valid one-call ticket polygon and excavation activity that encroaches upon underground facilities within a valid ticket polygon. Figure 1 provides a schematic of the system.

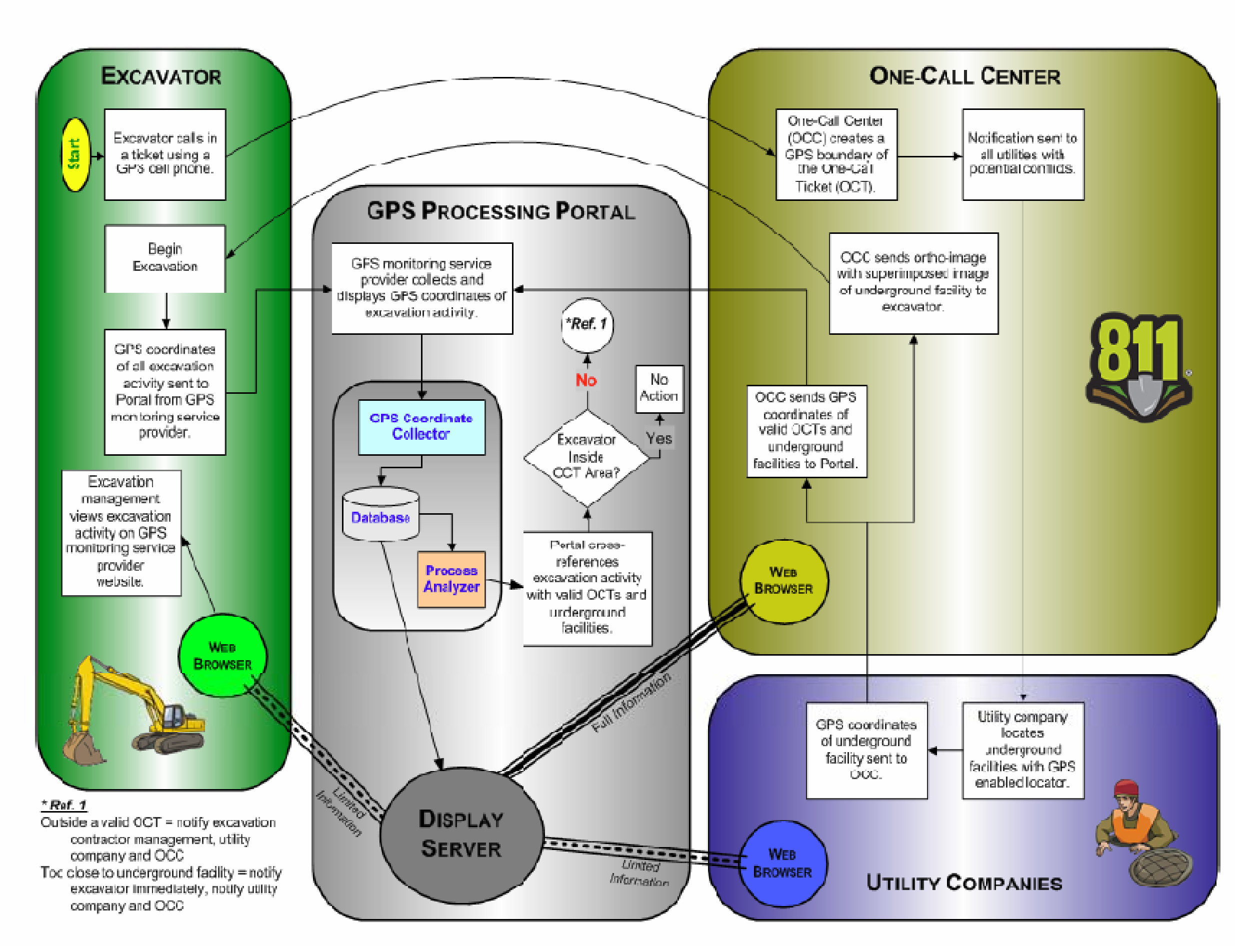


Figure 1. Schematic of Phase III System

A GPS monitoring system for excavation equipment was developed that periodically transmitted active excavation equipment location information to a portal. This information was cross referenced with the GPS coordinates of all valid one-call tickets.

A more precise GPS monitoring system was developed to cross reference the location of the excavation bucket with the GPS coordinates of underground facilities (as collected during the standard mark-out process with a GPS-enabled locator using Phase II technology). A warning was transmitted to the excavator, utility company, and/or one-call center when the bucket comes within a predetermined distance of a utility line.

Research Work

The research work in this project involved the development of a combination of new and existing technologies to create a system that provides a warning of excavation activity that is occurring outside of a valid one-call ticket boundary or that is occurring in close proximity to an underground facility. The objective of the project was to develop a system that allowed proof-of-concept testing to be performed.

Technology Overview

Phase III is the subject of this report but builds upon the procedures and technology demonstrated in Phase I and Phase II. The goals of Phase III include:

- Display the location of the excavation activity on an accurate digital photogrammetric map in near real-time using information from a GPS-based asset tracking system that includes a mechanism for determining when digging is occurring
- Demonstrate a notification system that provides a warning if an excavator digs outside of a valid one-call ticket polygon using data from the one-call center
- Demonstrate a notification system that provides equipment operators a warning if digging is occurring within a predetermined distance of underground facilities using data from a GPS-enabled locator

Phase III was broken into two sub-phases: Phase III-A and Phase III-B.

Phase III-A is the one-call violation monitoring system and consists of the following components:

- GPS asset tracking system for monitoring the general location of excavators (Trimble's Crosscheck)
- Digging trigger to allow the system to only be used when digging is actually occurring (Ocala's ExcaVision)
- Portal to gather data on the location of excavation activity and one-call ticket polygons (Guardian ProStar's ProStar Online).

Phase III-B is the encroachment notification system and consists of the following components:

- GPS-enabled locator to collect coordinate data of underground facilities during one-call locates (3M Dynatel, Trimble GeoXH, and TriGlobal's UtiliMapper)
- High accuracy GPS to determine the location of the bucket tip
- On-board software to import utility location data, detect encroachment, and provide a visual warning to equipment operators.

Phase III-A was tested and demonstrated with two excavation contractors and Phase III-B was tested with an equipment manufacturer and the Virginia Department of Transportation (VDOT).

Stakeholder Engagement

GTI held a project kick-off meeting on May 26, 2008 with a Steering Committee. The Steering Committee members include representatives from utility companies, one-call centers, contract locators, CGA, excavators and equipment manufacturers. The steering committee developed performance requirements for the various components, including:

- Frequency of data transmittal to the one-call center
- Frequency of data transmittal to the excavation contractor management
- Frequency of data transmittal to encroachment monitoring software
- Trigger for transmitting data to the one-call center
- Accuracy requirements for one-call violation application
- Accuracy requirements for the utility encroachment application
- Method for differentiating between the location of the antenna and the excavation bucket
- Acceptable cost
- Additional applications (e.g., fleet management and theft tracking) to make use of the technology more attractive to excavators.

GTI presented the project status to CGA's R&D committee at the CGA Excavation Safety Conference & Expo in Feb 2009. Feedback was received and included:

- Potential pilot participants
- Accuracy requirements
- Digging Trigger requirements
- Suggestions for working with equipment manufacturers to have the antennas integrated into the design of new equipment
- Suggestions for investigating current applications in the railroad industry
- False alarms
- Privacy concerns

The project was also presented at the Virginia Damage Prevention Conference to provide awareness to the contract locators, excavators, and other stakeholders that could be impacted by the project.

GTI also presented the project at the PHMSA R&D Forum on June 25th, 2009 and the 2010 CGA Conference.

GTI conducted two meetings with excavation equipment manufacturers to present the project concept and to determine future levels of participation.

Phase III-A

Work Flow

The first step in the project was to develop a realistic work flow to allow the system to be designed in a logical manner that supported the anticipated use case. The following work flow was developed for the Phase III-A system:

1. Excavator calls in a ticket using a GPS cell phone (Phase I technology)
2. One-call center creates a GPS boundary of the one-call ticket
3. One-call center sends GPS coordinates of valid tickets and underground facilities to Portal
4. GPS monitoring service provider collects and displays GPS coordinates of excavation activity
5. GPS coordinates of all excavation activity sent to Portal from GPS monitoring service provider
6. Portal cross-references excavation activity with valid one-call tickets
    a. If excavation is in a valid one-call ticket = no action
    b. If excavation is outside a valid one-call ticket = notify excavation contractor management, utility company and OCC
7. Utility and excavation management has limited viewing capabilities of Portal
8. Excavation management can be notified of violations through standard ticket management
9. Positive response from excavation management is recorded

The work flow described above was used to design the components of Phase III-A technology described below.

Excavation Monitor

The Excavation Monitor is composed of the digging trigger and the GPS excavation tracking system. The requirements for the Excavation Monitor were developed with support from the Steering Committee and included accuracy, cost, and functionality. Commercially available GPS antennas were reviewed to determine if any could meet the system requirements. The Trimble Crosscheck and Asset Management System were identified as meeting the majority of the requirements for the GPS excavation tracking system. Trimble's Asset Management System has on-line reporting that can be used to view and transmit data related to excavation activity and location.

The Ocala ExcaVision system was selected for the digging trigger after a technology search did not uncover any commercially available digging triggers. The ExcaVision met the performance requirements but was more expensive than anticipated due to the additional functionality that the system provides including precise depth information and visual display. The ExcaVision was selected for use in the project because it met the technical performance requirements, was commercially available, and had a sales and support network in place. The assumption was that it would be more straightforward to develop a lower cost, lower functionality device through Ocala than to develop an entirely new product. GTI and the Steering Committee developed several concepts for alternative digging trigger mechanisms but the Ocala ExcaVision was ultimately selected based on its commercial availability.

GTI worked with Trimble and Ocala to modify the CrossCheck and the ExcaVision systems to create the Excavation Monitor. Minor software modifications were required to allow the integration of the ExcaVision with Trimble's on-line Asset Management System. The CrossCheck reported back the digging status and location as well as other asset information such as speed. Figure 2 shows the configuration of the integration of the ExcaVision and CrossCheck system.

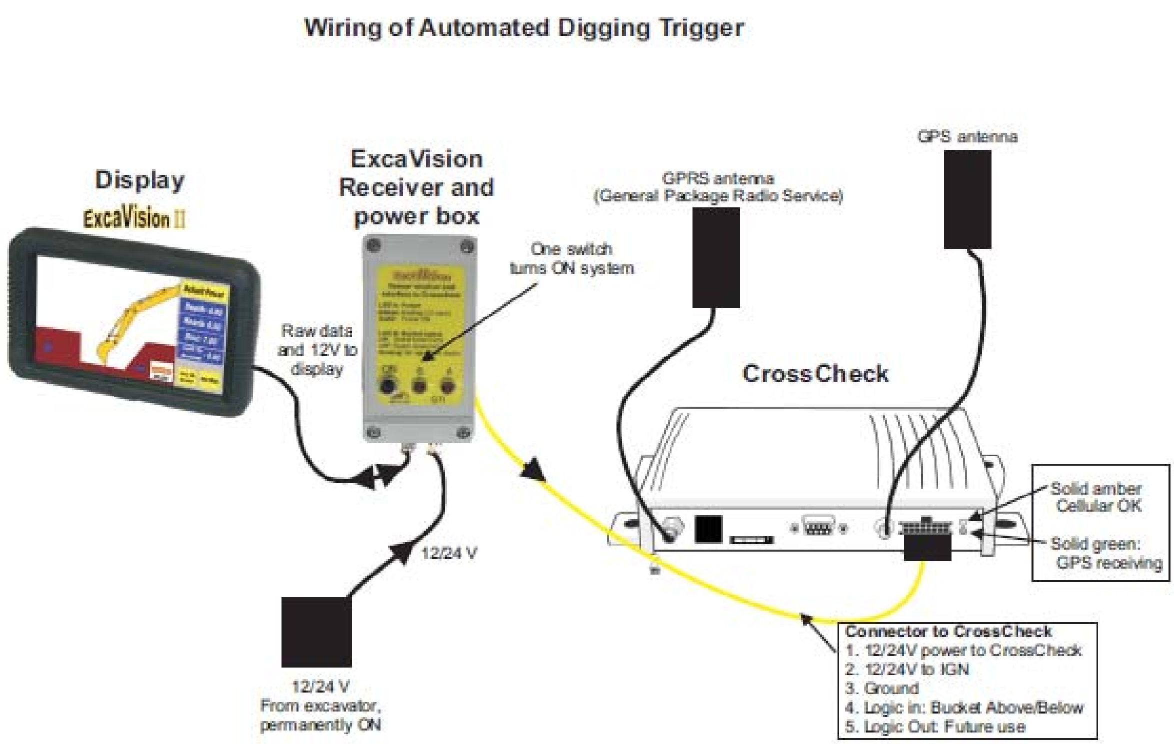


Figure 2. Excavation Monitor Using Trimble's CrossCheck and Ocala's ExcaVision

The data originates from a Trimble Crosscheck monitor that is mounted on the excavator. GTI developed the means for encoding the digging status of the excavator with these switches. When a switch changes state, a "sensor event" is generated and sent to the Trimble website.

Five Excavation Monitoring prototypes were built for installation with excavators for testing and demonstration.

One-Call Violation Monitoring Software

Software was created to collect the excavation activity data from Trimble's Asset Management System and one-call ticket data from the one-call center. Guardian ProStar's ProStar Online system was selected as the portal that would collect this data and provide an interface for viewing excavation activity. Appendix A – Guardian ProStar Report provides a full description of the ProStar Online portal and software and Figure 3-Figure 7 show screenshots.

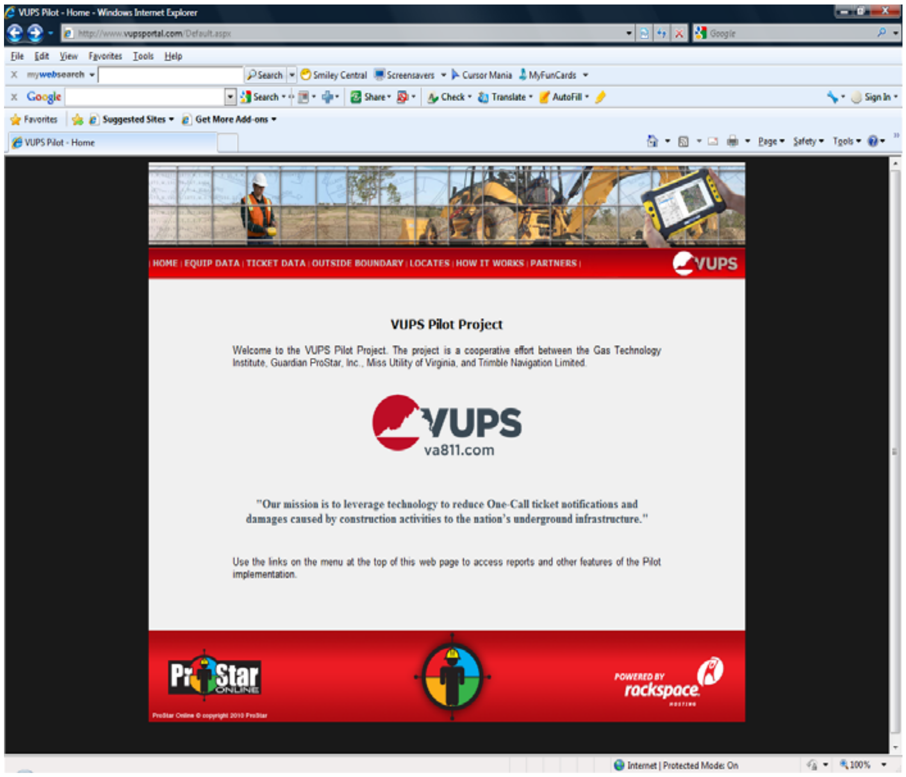


Figure 3. Opening Screen of the ProStar Portal

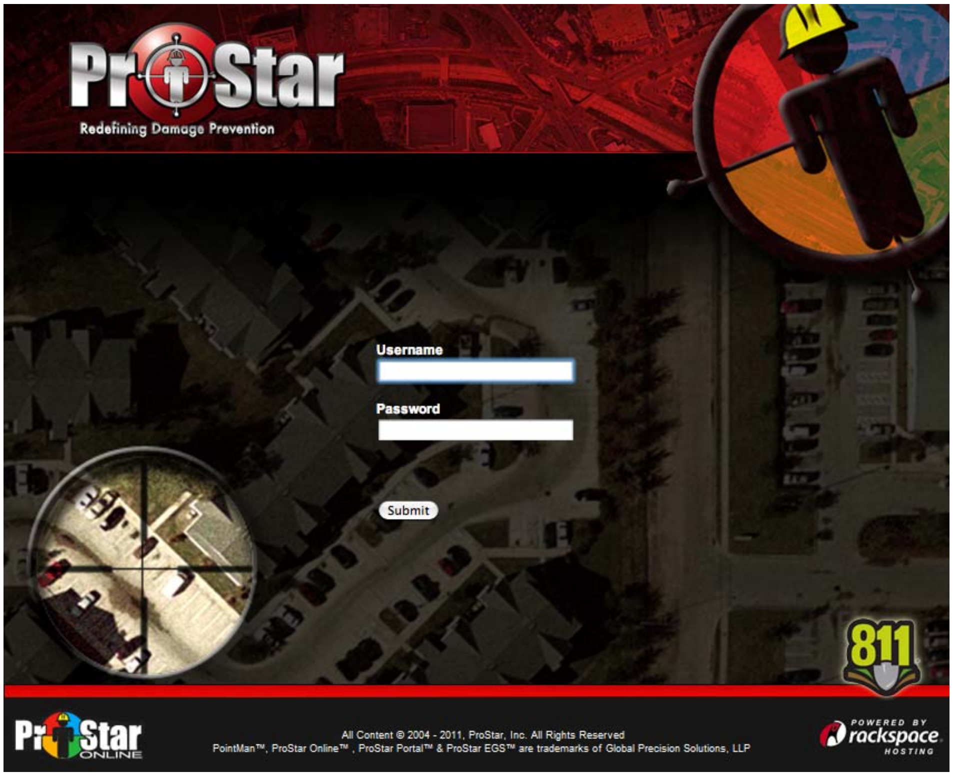


Figure 4. ProStar Portal Login Screen

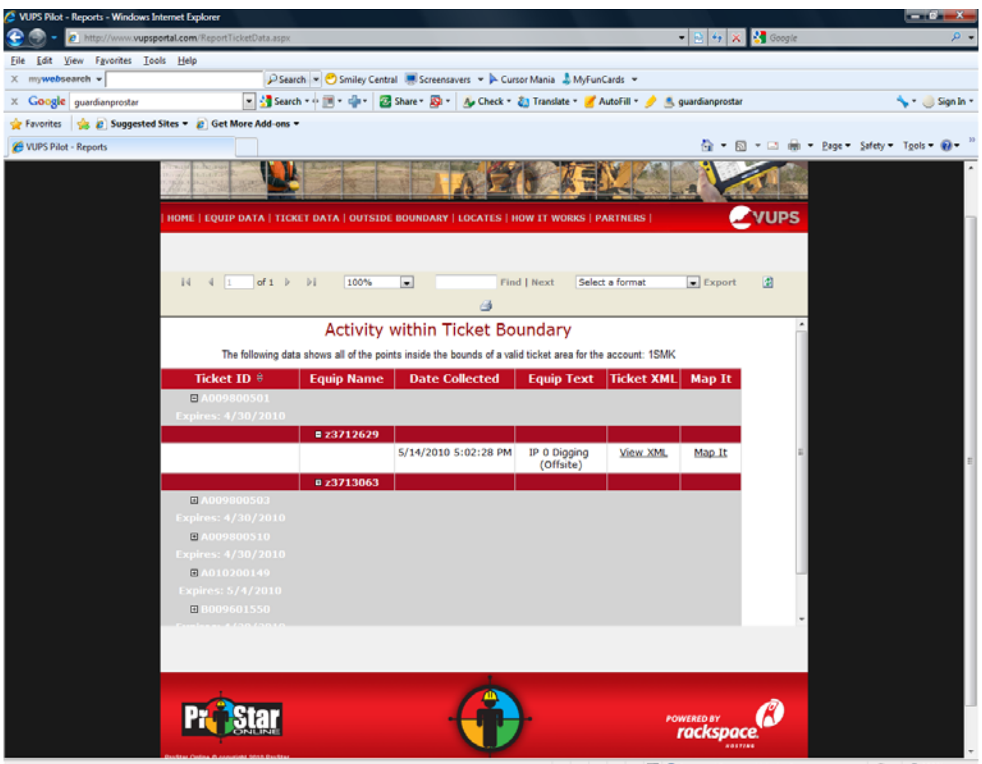


Figure 5. ProStar Portal Reporting Screen

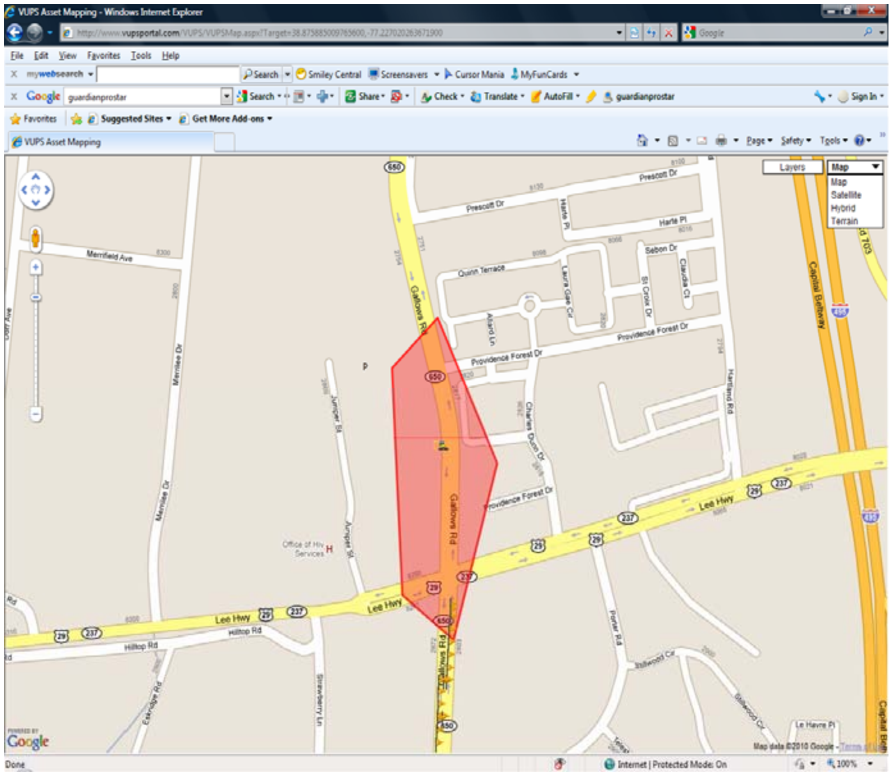


Figure 6. ProStar Portal Mapping Display

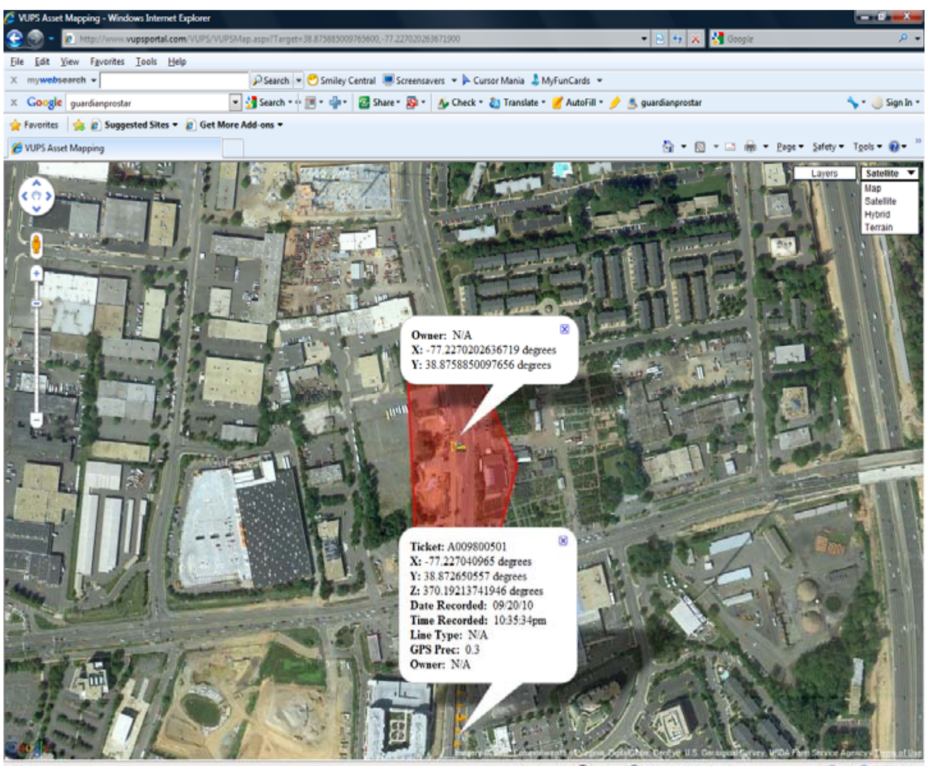


Figure 7. ProStar Portal Mapping Display with Feature Data

Data Flow

The flowchart in Figure 8 shows the data flow for Phase III-A.

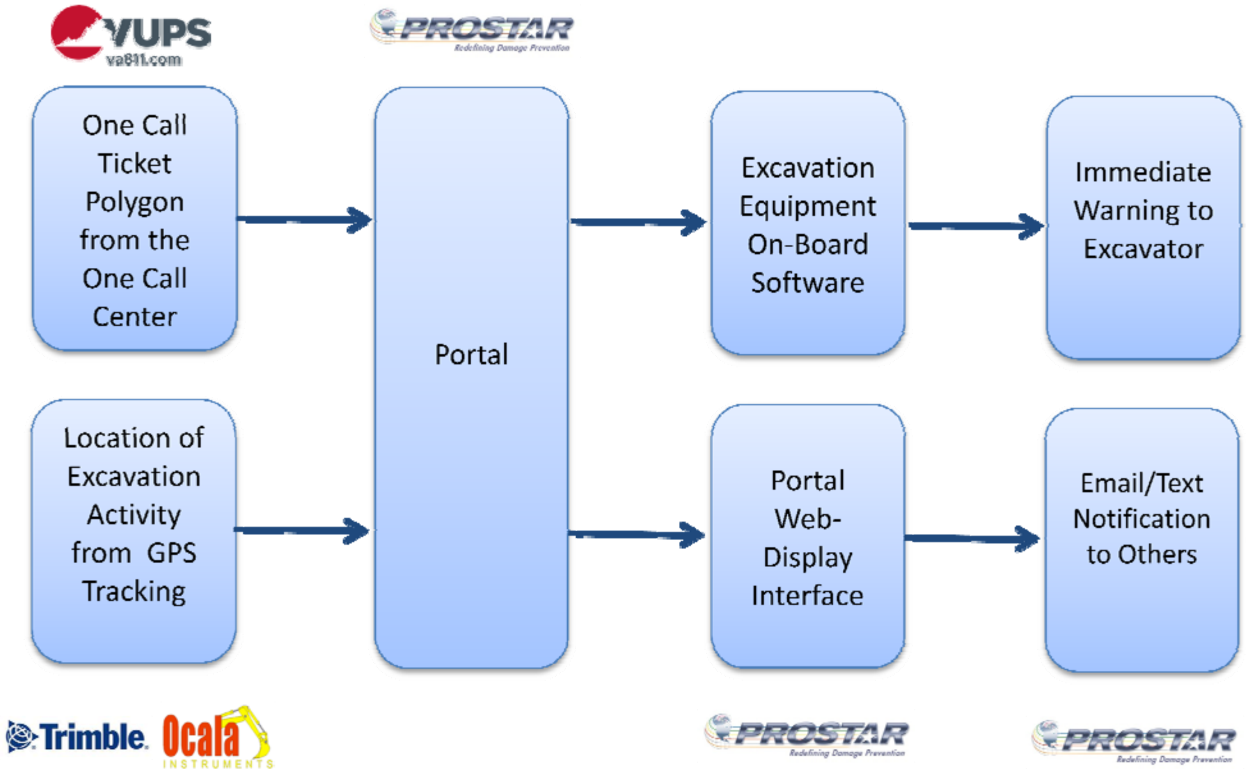


Figure 8. Data Flow for Phase III-A

Demonstration

Phase III-A technology was demonstrated with two excavation contractors in Virginia. Two Excavation Monitoring systems with the CrossCheck and Excavation equipment were installed on two backhoes with an excavation contractor in Williamsburg, VA. The equipment operators used the Excavation Monitoring system and the excavation activity was successfully reported back to the Trimble Asset Management System. Figure 9 and Figure 10 show the installed Excavation Monitor.

Figure 9. Digging Trigger Sensors

Figure 10. ExcaVision Viewing Screen

Two additional Excavation Monitor systems were installed with and excavation contractor for work on a VDOT project site in Gainesville, VA.

ProStar Online then retrieved the excavation activity data from Trimble for consumption by the portal. Figure 11 shows a screenshot of ProStar Online displaying the location of an excavator within a one-call ticket polygon.

Figure 11. ProStar Portal Displaying Excavation Activity and One-Call Ticket Polygon

GTI conducted a workshop with Phase III-A participants to gather feedback on the performance of the system and to determine modifications that would be necessary for commercialization. The feedback indicated that the digging trigger should have less components and better battery life. One of the excavation contractors that participated in the demonstration indicated that the ability to view excavation activity on a handheld device would provide the ideal functionality.

Based on the end-user feedback, GTI developed a modified Excavation Monitor system that enclosed the ExcaVision and CrossCheck into one unit as shown in Figure 12. Three of the beta prototypes were installed on excavation equipment with an excavation contractor for testing and demonstration.

Figure 12. Excavation Monitor Beta Prototype

Upon successful testing of the beta prototype developed by GTI, Ocala developed a pre-production version shown in Figure 13.

Appendix B – ExcaVision Brochure provides a brochure of the commercially available Digging Trigger.

Figure 13. Commercially Available Digging Trigger

Phase III-B

Work Flow

A workflow for Phase III-B was also developed to guide the technology development.

1. Excavator calls in a ticket using a GPS cell phone (Phase I technology)
2. One-call center creates a GPS boundary of the one-call ticket
3. Notification sent to all utilities with potential conflicts
4. Utility company locates underground facilities with GPS enabled locator (Phase II technology)
5. GPS coordinates of underground facility sent to the one-call center
6. One-call center sends ortho-image with superimposed image of underground facility to excavator
7. One-call center sends GPS coordinates of valid tickets and underground facilities to Portal
8. Portal sends GPS coordinates of valid one-call tickets and underground facility location data to excavators with high-accuracy GPS and on-board monitoring software
9. Excavator receives a warning from the on-board monitoring system when digging encroaches underground facilities

Technology

The technology for Phase III-B provides a system that warns equipment operators when digging is occurring in proximity to an underground facility. The precision of the GPS required to achieve this level of monitor is significantly higher than Phase III-A. The system must be accurate to within 12" in order to provide an effective mechanism for determining the distance between the tip of the bucket and the underground facility. High accuracy GPS is required for both the GPS-enabled locator and the excavation equipment monitor.

GPS-Enabled Locator

GTI selected the 3M Dynatel Locator for the project because it was able to integrate with two different GPS receiver manufacturers. Trimble's GeoXH receiver and TriGlobal's UtiliMapper software were used with the 3M Dynatel Locator to collect precision GPS data of utility locates. It should be noted that there are several other commercially available locator/GPS/software combinations that could be used to meet the same functional requirements including the technology being used by VUPS in Phase II. The particular combination selected for this project was based on cost, ease-of-use, and familiarity of the technology to project participants. Additionally, the 3M Dynatel Locator has the ability to program, locate, and read Radio Frequency Identification (RFID) tags. It was envisioned that RFID technology could also be integrated into Phase III technology in the future.

Excavation Monitoring

GTI originally intended on developing a modular high-accuracy GPS tracking system for excavation equipment that could be retrofit onto older equipment. However, it was determined by GTI and the Steering Committee that the high cost of the system would be prohibitive. The estimated cost of a GPS system that could be retrofit onto excavation equipment that could monitor the location of the bucket tip to within 12” in real-time was over $20,000 and could ultimately have been as high as $50,000. GTI consulted with manufacturers of GPS and excavation equipment to determine if alternatives existed but it was realized that the performance requirements could not be met with a lower cost system.

However, many new models of excavation equipment are designed with an on-board high accuracy GPS that provide the required precision. GTI engaged two large equipment manufacturers to determine their interest in supporting the objectives of Phase III-B and incorporating damage prevention monitoring technology directly into their equipment and software. Both manufacturers expressed interest and agreed to allocate resources to support the development and demonstration of excavation monitoring technology.

Both equipment manufacturers had the ability to create avoidance zone polygons. One manufacturer created a software feature that specifically created avoidance zones for utility line data.

Data Flow

The flowchart in Figure 14 shows the data flow for Phase III-B.

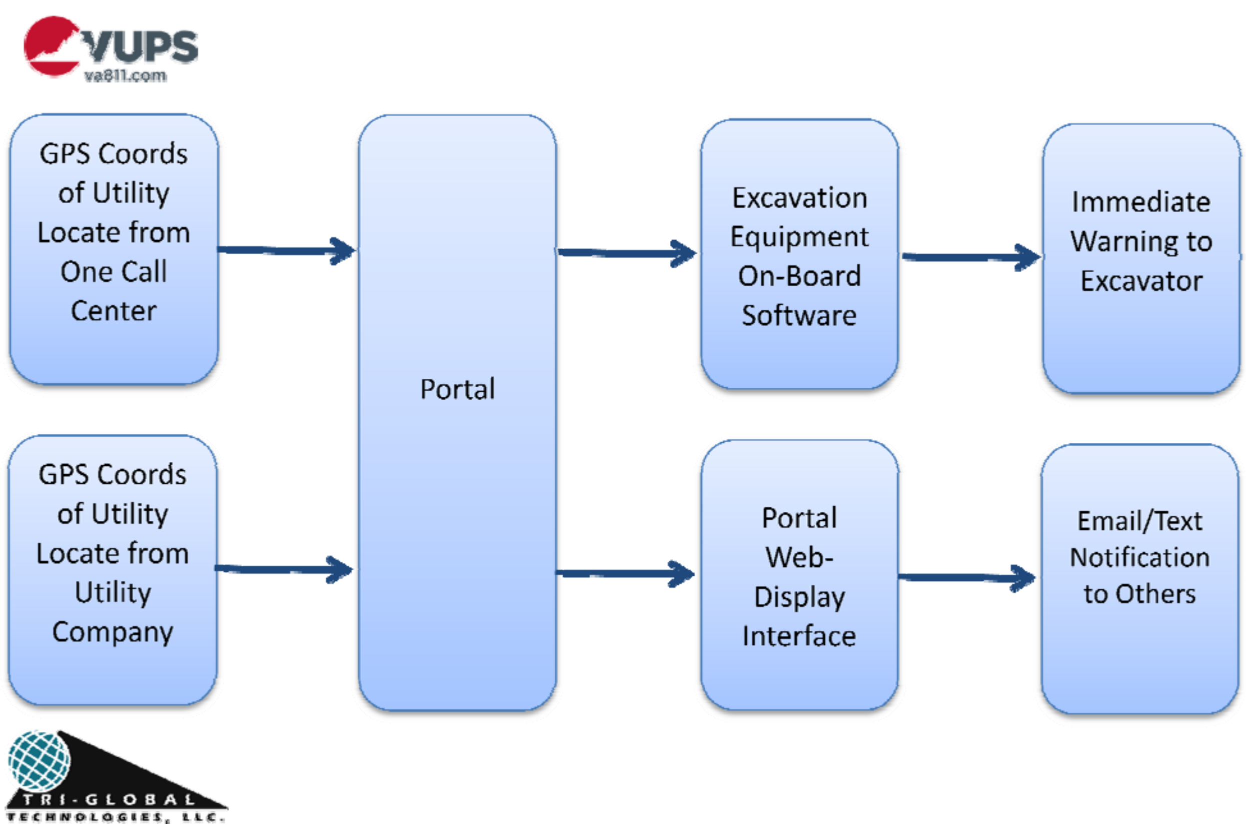


Figure 14. Data Flow for Phase III-B

Demonstration

Phase III-B technology was demonstrated in Virginia on August 25, 2011 with support from VDOT and one of the equipment manufacturers. Utility locate data was collected with the 3M/Trimble/TriGlobal GPS-enabled locator. The collected GPS data was converted to .dxf format and exported to the on-board software from the equipment manufacturer. The new damage prevention software feature created an exclusion zone around each of the utility lines and created a warning when the backhoe began digging within 24" of the buried utility.

During the demonstration, the excavation equipment simulated digging over a utility line and the on-board software detected the encroachment and provided a warning to the equipment operator. The warning "WARNING, you have entered a critical zone" was displayed on the equipment operator's screen when digging was simulated near the utility line.

After the demonstration was complete, GTI led a debriefing to gather information from the participants that included excavation contractors, utility operators, DOTs, equipment manufacturers, and other technology providers.

The concept of the GPS-Based Excavation Encroachment Notification system was well received but participants emphasized the importance of low cost and simplicity. Some participants expressed concerns with the potential for distraction of the equipment operator and suggested that the warning be provided to a foreman or other job site supervisor instead of the equipment operator.

Two other technologies developed by GTI that were not part of the SOW for Phase III but that provide related functions were also demonstrated. The first was an application that captured the GPS coordinates of RFID marker ball installations and provided real-time viewing capabilities on smart phone and tablet devices. The second technology utilized the same GTI software to use smart phones and tablet devices to capture the GPS coordinates of one-call ticket boundaries to support Phase 1 Electronic Whitelining.

Implementation Guidelines

Based on the experiences of the Phase III project and general technology implementation best practices, the following Implementation Guidelines have been developed for subsequent pilot projects:

- **Stakeholders**
  - All stakeholders that could be impacted by the pilot project should be identified including regulatory agencies, one-call centers, operators and utility companies, excavation contractors, and regional trade associations.
  - Communications with stakeholders should be formalized and should start at the project conception stage through completion.

- **Executive Sponsors**
  - Each stakeholder group should have at least one Executive Sponsor that regularly and visibly supports the project. Executive level support is needed to link corporate goals to the objectives of the project. For example, a utility company executive could link excavation monitoring to a corporate goal of risk reduction, reduced fines or integrity management. An excavation company would link the project to improved safety or reduced downtime.
  - Executive level support will provide the incentive to end-users to use the technology as intended during the pilot project. Using the technology should not be optional and should not be at the discretion of the field user. Executive Sponsors should emphasize a "deploy" mentality and not a "permission to adopt" mentality.

- **Steering Committee**
  - A Steering Committee should be developed that makes decisions regarding the scope, objectives, metrics, technology selection, and implementation strategy for the pilot project.
  - Each stakeholder group should have at least one representative on the Steering Committee and ideally each company involved should have a representative. The Steering Committee should not only have broad representation across different industry stakeholders but should also include representatives from different functions. For example, committee membership should include participants outside of the Damage Prevention and Locating department and should include representatives from Engineering and IT. At least one Executive Sponsor should participate in each Steering Committee meeting.
  - The Steering Committee should be formed at the project conception stage and should meet regularly and deliberately throughout the project. The roles and responsibilities of the committee members should be clearly articulated.
  - Steering Committee members should have the authority to commit resources from their organization.
  - The Steering Committee should be responsible for leading the technology selection process.
  - Depending on the skill sets of the committee, an independent technology consultant could be utilized to assist in the technology selection process. Information technologies are evolving at a rapid rate and subject matter experts may be able to provide professional, non-biased recommendations. For example, recent advances in smart phone and tablet device technology have provided a new level of functionality that could be leveraged for excavation monitoring in real-time in the field.
  - The Steering Committee should provide regular and frequent guidance and feedback to the Implementation Team (described below).

- **Implementation Team**
  - An Implementation Team should be established to execute the project defined by the Steering Committee. The team should consist of the resources needed to

deploy the selected technology as well as the end users that will participate in the pilot project.
  - Depending on the skill sets of the team, it may be beneficial to have an independent project manager to manage scope, schedule, and budget.
  - The Implementation Team should be formed by the Steering Committee once the scope of the project has been defined. The team should meet regularly and deliberately to review scope, schedule, and budget. The roles and responsibilities of team members should be clearly articulated including a Team Leader function.
  - End users that will participate in the pilot project, including contract locators and excavation equipment operators, should be carefully selected to provide a realistic representation of the larger end-user group. Pilot participants should be willing to learn new technologies and accept new processes, but should also represent the typical skill set and background of other end-users.
  - The team should develop a process for identifying issues throughout the project and determining which issues are critical and could lead to implementation failure and which simply require additional training or minor modifications. Mechanisms for obtaining regular and structured feedback from the end-users should be incorporated.

- **Technology Selection**
  - Technology selection should be lead by the Steering Committee. A committee member with IT and technology implementation experience should be tasked to lead the architecture design and vendor selection process.
  - Technology selection should strongly consider those technologies that support the spatial definition functions commonly found in government agencies. Technology selection should be made with the basic principles of integration across multiple organizations and look for underlying technology solutions that support these principles. The data processing environment be selected that does not require grassroots development of new technologies.
  - Technologies that are sufficiently developed to support mobile computing should be selected. Mobile computing technologies for users to define one-call tickets and view excavation activity areas should be sufficiently simple to use and should be based on computing architectures that can be integrated across a broad spectrum of businesses and users.
  - The scale of pilot project should be clearly defined before specific technology is selected. The goal of the pilot project may be to simply prove the concept of monitoring excavation activity with GPS with the understanding that the pilot project technology will not be the same as that selected for full implementation. This option may be selected for cost or schedule reasons. Alternatively, it may be desired to select technologies that have the ability to scale up to full implementation. Either approach can be used based on circumstances, however it should be clear which approach is being taken before the technology selection process begins. If the technology is expected to scale-up to for full implementation, considerations for proprietary vs open and off-the-shelf vs customized systems should be carefully evaluated in the context of the project and the implications for other stakeholders.

- An RFP process should be used to select the technology and service providers for the pilot project. A careful review of the ability and willingness of the technology and/or service providers to modify their offering to meet the project objectives should be conducted. For example, Trimble made modifications to their web-reporting function to provide the required information to the portal. Ocala Instruments modified their standard product to provide the digging trigger functionality.

- **Training and Support**
  - The importance of through and consistent training cannot be overemphasized. All end-users should be provided with appropriate classroom and field as well as continuous training throughout the duration of the pilot project.
  - End-users should have a clear point of contact for resolving technical issues. For example, excavators should have the phone number of a technician that they can call directly to troubleshoot problems with the GPS receiver. Simple technology issues should not have to wait for a meeting to get resolved.

- **Metrics**
  - The Steering Committee should develop metrics to evaluate the effectiveness of the system in relation to expectations. Frequent and regular meetings between members of the Steering Committee and the Implementation Team should be conducted to monitor progress and ensure that the appropriate data is being collected.
  - The Steering Committee should evaluate the performance of the system throughout the pilot project and make changes as necessary to ensure that the technology is effectively addressing the root causes of excavation damage.

Summary and Recommendations

The objective of the project was to demonstrate the concept of utilizing GPS tracking to prevent excavation damage. The results of this project successfully demonstrated the ability to track excavation activity and report one-call violations and underground facility encroachment. User feedback supported the concept of the technology but also provided guidance on improvements to turn the technology into a commercial product with the potential for national adoption.

Technology

Recent advances in GPS, Geographic Information Systems, cloud computing, and other supporting technologies will allow the Phase III (as well as Phase I and Phase II) technology to be provided at a lower cost using simpler technology. GTI will work with current technology providers while investigating new innovations to continue to develop the hardware and software that will be required for further implementation in other states.

Implementation

User acceptance of Phase III technology will be the primary barrier to implementation. Additional support and motivation will need to be provided to encourage adoption. Increased regulatory focus and punitive measures related to excavation damage prevention will provide some of the required motivation for adopting advanced locating, mapping, tracking, and warning technologies. However, some specific mechanisms for encouraging the adoption of Phase III technology could include:

- Utility companies could require that contractors bidding on work utilize the GPS-based EEN system
- Utility companies provide GPS-based EEN systems to excavators performing work in critical or high congestion areas
- The GPS-based EEN could be mandated by the state as an alternative to fines for violators of state laws.
- Additional capabilities could be built into the GPS-based EEN system to encourage excavation contracts to want to use the system. Fleet tracking and personnel management capabilities could easily be integrated into system. Additionally, the system could be developed that allows management at excavation contractors to be notified of violations before other enforcement organizations are notified. This will provide the contractor a means to reduce exposure to excavation damage while avoiding fines.
- Excavation equipment manufacturers can make GPS tracking and avoidance zone systems more universal in new equipment.

It is expected that the excavation community will embrace Phase III technology if the cost of the equipment is low and the system is easy to use. To accomplish this, GTI will continue to develop Phase III-A and Phase III-B technology separately with the realization that one-call violation monitoring will be more feasible for rapid and widespread adoption due to the lower cost.

GTI will continue to solicit participation for pilot projects in Virginia and other states. Additional pilot projects will allow new technologies to be deployed and tested. Pilot projects will also create the awareness and market pull that will encourage further innovation leading to cost savings. Funding to support pilot projects and the capital investments required to implement Phase III technology will likely be needed to support further adoption.

List of Acronyms

Acronym	Description
CGA	Common Ground Alliance
DOT	Department of Transportation
EEN	Excavation Encroachment Notification
GPS	Global Positioning System
GTI	Gas Technology Institute
PHMSA	Pipeline Hazardous Materials Safety Administration
R&D	Research and Development
RFID	Radio Frequency Identification
SOW	Statement of Work
VDOT	Virginia Department of Transportation
VUPS	Virginia Utility Protection Services

Appendix A – Guardian ProStar Report

VUPS PILOT PROJECT FINAL REPORT

OVERVIEW

In the U.S. alone, there are over 35 million miles of utility assets buried below ground. Due to disparate data management practices, this colossal amount of data is often inaccurate, incomplete, difficult to interpret, out-of-date, illegible, or simply inaccessible. Every utility owner has some form of archived records, in either static or dynamic format. However, with no industry standards for utility data management practices and existing processes based on a myriad of formats and technologies, the records are of limited value.

The source of this disjointed data issue has been the inefficient data management practices and not effectively capturing and storing the data gathered during the initial utility installations or during the utility locating and mark out processes that occur prior to any proposed construction.

Before any construction project begins, utility companies by law are notified by a state one call center when information they have been provided indicates that the proposed construction project could potentially cause conflict with the utility's buried assets. Those utility owners then receive a ticket notification from the state one call center, which is a request to place markings at the approximate locations of their assets in the vicinity of the construction for the safety of the construction crew and the public. Locators are then deployed and use locate devices in order to identify and mark the approximate location of the buried asset. To mark the asset locations, mark-outs are painted on the ground or small flags are placed to identify the asset's location. These markings are created using varying methods for both the collection, storage and management of the data and often placed where ground breaking operations will occur, making them difficult to share amongst the disciplines involved and temporary by nature. This makes the entire exercise almost pointless, as the mark outs are not recorded, quite often run over, wiped out or quickly disregarded by field crews and equipment operators.

To compensate for the poor records issue and not knowing the precise location of the assets, whenever a construction project is proposed in the assumed proximity of a utility's asset locations, utility companies are forced to require a very large buffer zone around their asset's assumed locations to accommodate for this lack of confidence issue. These large buffer zones result in an unnecessary amount of mark outs as the actual construction zone is often only a very small area inside the marked out area of suspected conflict concerns.

The industry is well aware that the disparity and imprecision of the current asset management practices is the cause of a large number of "over-notifications" which costs utilities millions of dollars each year. However, an even greater and more costly concern are the disruptions to life and commerce that often result in loss of life and irreparable damage to our environment when conflict occurs.

To address this disjointed and ineffective process, GTI and Guardian ProStar, Inc. "ProStar" engaged in a research & development project for the enhancement and implementation of a GPS based Excavation Encroachment and Ticket Notification system. GTI and ProStar would collaborate to create a comprehensive solution utilizing recent advent in technologies, along with existing practices, and work with a group of utility operators, excavators, locators and various state regulatory agencies in the state of Virginia, dedicated to providing a premier One Call Ticket Notification and Damage Prevention Solution.

ProStar and GTI began discovery, including the design & scope requirements of the project in late fall of 2008 and, in January 2009, the development of a comprehensive utility asset management and damage prevention system commenced. The mission of the project would be to work closely with the Virginia Utility Protection Service (VUPS), Trimble, Caterpillar, John Deere, Tri-Global, NiSource, and PHMSA/USDOT. The goal would be to improve the One Call Ticket Notification systems as well as excavation guidance operations through digital information distribution methods and the capturing, storing and display of more precise location data utilizing Global Positioning Systems, web services and mobile applications. Once completed, an improved process would provide

Page 1

better location information through more efficient data life cycle processes using advancements in GPS, mobile applications and web based solutions and be "open" in order to promote collaboration and data sharing amongst all the required stake holders in any given project.

VUPS PILOT PROJECT OBJECTIVES

The purpose of the Virginia Pilot Project was to develop and implement new and existing technology to improve the data communication processes among one-call centers, underground facility operators, facility locators and excavators. The primary focus of the project was to incorporate GPS location coordinates in excavation locate requests, to enhance the effectiveness and efficiency of the one-call damage prevention process. It was determined by GTI that because of the knowledge and findings previously gained in the Virginia Pilot Project (VUPS), that VUPS would provide a viable environment for the development of GTI's initiative, including a GPS based one call ticket and excavation encroachment notification system. The goals of the existing VUPS project and data life cycle processes would serve as the primary foundation for GTI's enhanced research and development initiatives that included a data management system that was web based and utilized mobile applications for data access and location awareness of utility infrastructure and heavy equipment.

The VUPS project was split into three phases:

Phase 1 – Electronic Whitelining (GPS-Based Cell Phones for One-Call Tickets)
Phase 2 – Electronic Manifest (GPS-Enabled Locators for Utility Mark Outs)
Phase 3 – GPS Based Excavation Encroachment Notification

Phase One: Electronic Whitelining

Electronic White Lining consisted of the excavator using GPS enabled mobile device to accurately identify the coordinates (latitude and longitude) of the planned excavation site. Excavation areas were defined either by a single GPS point, multiple points defining a line, or a polygon area. The excavator created an electronic "locate request" utilizing software developed for the Pilot Project and electronically transmits it from either the field or the office to VUPS via the Internet, creating a completed ticket. This phase of the project demonstrated that the application of GPS technology could be of significant benefit to the one-call process. The reduction in the number of outgoing notification tickets are considered significant and should result in significant savings in locate costs. The more significant outcome was the reduction in average site boundary or "polygon size" which provided tangible benefits to all stakeholders and included a significant reduction in ticket requests and improvements in safety.

Phase Two: GPS Facility Location

Phase II of the project, involved integrating GPS technology into locating instruments. This phase acquired GPS coordinates of underground facilities and created an electronic manifest of the locator's activity. This phase would provide the utility with improved location data of their assets by capturing and recording the location coordinates and provide an operator an electronic manifest, for a bird's eye view of the excavation area with all marked facilities.

Phase Three: Excavation Monitoring

Excavation Monitoring: Phase III consisted of integrating Trimble's Asset Management Program with the latitude and longitude coordinates of a ticket's excavation polygon area. Tools would be developed for a GPS-based excavation encroachment monitoring system in collaboration with Trimble, Caterpillar and John Deere to determine the feasibility of the concept and integration into heavy equipment on board display systems.

Page 2

GPS monitoring systems would send information from the excavating equipment to the server where it would be compared with a project site electronic manifest of any previously collected data and existing locate tickets. This system would cross-reference the GPS coordinates of the excavating equipment to the GPS coordinates of the utilities in order to provide warnings, including distances from the utility to the equipment when an encroachment existed within a fixed tolerance zone of the underlying facility, as well as excavating operations outside a valid one call ticket boundary. Excavating equipment could even be equipped with a GPS device and a trigger mechanism to indicate when excavations commenced.

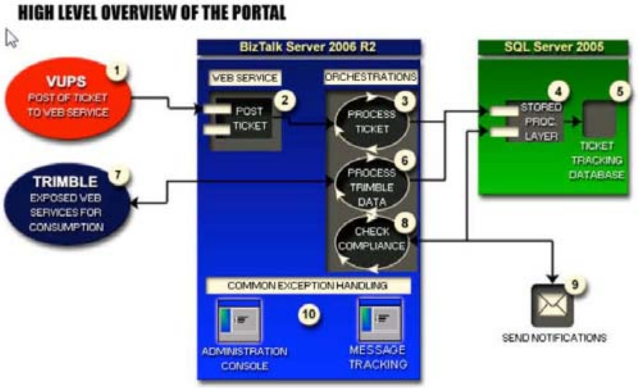
VUPS PILOT PROJECT TECHNICAL WORK

Data mapping and integration requirements for the data collection, data storage and data display, would be achieved by creating electronic locate tickets, mapping proposed construction site boundaries onto orthographic layers and capturing digital mark-outs with GPS enabled locate devices. These hybrid devices would also record the associated metadata required to identify the data footprinting, including the business rules and methods applied to the data collection process.

For the VUPS Pilot Project, The VUPS current One Call Ticket management system was used to provide the proposed ticket boundary area, Tri-Global Technologies and the Tri-Global Mobile Utility Suite was used to integrate GPS systems into Data Locate Hardware in order to provide the coordinates of the buried assets locations and Trimble/CAT construction systems were used to identify heavy equipment locations.

In order to fulfill the data lifecycle and technical requirements specified, ProStar's patented ProStar Online™ was utilized as the integration tool and computing platform designed to collect, manage and ultimately distribute & display the location data. The ProStar Online integration platform leveraged numerous proprietary processes and several technological standards, including Web services, Google Maps, Reporting Services, BizTalk, SQL Server and XML to create the data management systems and web portal interface.

HIGH LEVEL OVERVIEW OF THE PORTAL



The preliminary design, system set up and configuration would be completed on ProStar's internal development servers with project implementation migrated to a Class 1 hosted server platform. ProStar's partner Rackspace, the world's largest Class 1 hosted facility was selected to ensure nationwide scalability and address any future support and security concerns. Additionally, moving the portal and operational platforms to a co-hosted provider would significantly reduce any IT costs for clients and permit stakeholders to focus on their own business models and less on managing internal hardware and software systems required to support the project's developments.

ProStar Online was set up and configured to enable the integration with VUPS Pilot Project stakeholders existing business practices, including project site data, One Call Ticket Notifications and heavy equipment operations in order to create GPS-centric reports and analytics.

It was mission critical that the system could capture and record the data source information or "data foot printing" through well defined data collection processes throughout the asset data life cycle. The data would have to be captured, stored, processed and readily available to be shared across all required disciplines and provide both the data precision and data pedigree of all the relevant data sources. Once validated, this information could then provide quantifiable and measurable data foot printing into all phases of construction and damage prevention practices. The ProStar Online systems would capture and store the GPS coordinates including the data footprinting of the project site, One Call Ticket boundaries, utility locations and the heavy equipment positioning, as well as all other relevant location information such as who, where, how and when the data was captured and collected. The data foot printing would be mission critical, in order to provide the asset location confidence levels to field crews and equipment operators or anyone else responsible for making key decisions based on asset position awareness.

For The Virginia Pilot Project NAD 83 as the datum and decimal degrees as the format were used. The National Pipeline Mapping System also prefers NAD 83 and decimal degrees. To maintain consistency with these previous initiatives, recent recommendations propose that One Call systems adopt NAD 83 and decimal degrees (using a minimum of 6 decimal place digits) as the standard GPS nomenclature for One Call use. The WGS84 datum (the default setting for most GPS units) is virtually identical throughout North America, and should also be accepted.

VUPS PILOT PROJECT DELIVERABLE

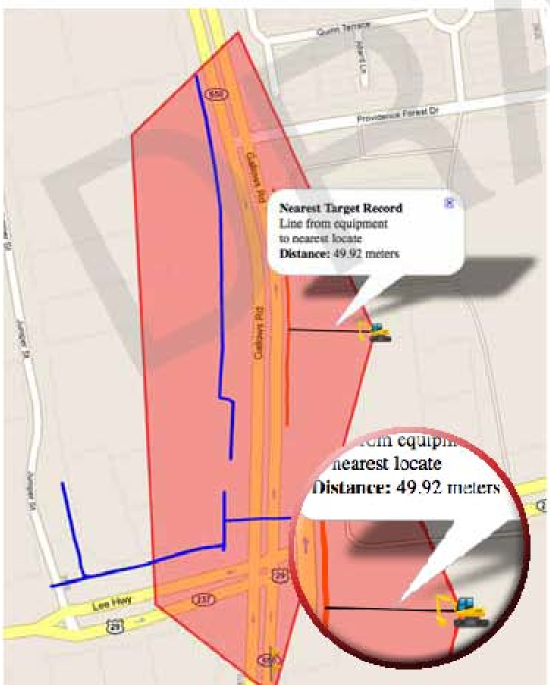
The VUPS Pilot Project deliverable included the configuration and implementation of ProStar's ProStar Online and the ProStar Portal. ProStar Online integrated ProStar's proprietary systems with stake holder's existing technologies and business practices and followed specific command and business rules protocols to meet project specifications. This business rules based computing platform and integration tool utilizing BizTalk Server, services clients through a Cloud Network via the ProStar Portal. The system supports DOD level security network links as well as designated user privileges using password protocols.

ProStar Online™ utilizes XML, a global language standard that promotes interoperability among all required operating systems including, legacy technologies as well as future system applications, including computer hardware and software. This standard language and interface interoperability promotes collaboration between existing systems of the contractors, excavators, locators and utility owners.

ProStar's extensive integration tools have the ability to map to a variety of formats. One such format implemented was DXF, a common standard for most CAD based systems. ProStar created and utilized DXF file formats in order to push project asset location data into Caterpillar's AccuGrade system as well as John Deere's ARRIS CAD systems.

Using ProStar Online's data management processes, VUPS project stakeholders send project site data to the ProStar Online hosted server via a secure web-portal called The ProStar Portal, where it is cross-referenced and integrated with other data, then made available for viewing by all the authorized agencies.

ProStar Online is a transactional database which means that an inherent audit trail of every data transaction and/or edit, including "who, what, when, where, and how" the data was recorded. The system captures and records "all" transactions and following QA processes, posts the "most recent" or "most valuable" data sets to the viewer along with its updated pedigree and precision data footprints.



Google Maps layer feature has been selected and the Ticket Boundary area as well as heavy equipment position relative to distance to closest conflict is being displayed.

VUPS One Call Ticket datasets are emailed using an FTP server where polygon and other boundary data sets are extrapolated to become digitally interfaced with project site data using XML. Data locators are then deployed to provide locate information in relation to the One Call Ticket boundary with mark outs of the utilities using Digital markings. GPS enabled locate devices would provide the GPS PDOP readings as well as record all the meta data associated to the methods of the data collection practices and methods being used.

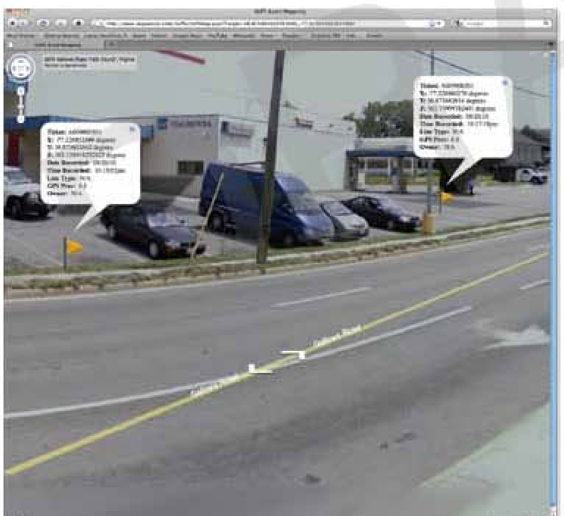
FTP: File Transfer Protocol - a term used to identify the protocol for exchanging files over the internet, PDOP: Positional Dilution of Precision - a term used to specify the additional multiplicative effect of GPS satellite geometry on GPS precision

ProStar Online™ utilizes Web Services in order to support the Cloud and its subscribers. This means that subscribers can view data stored on the platform servers through a portal from any browser installed with an appropriate plug-in and enables users to view project site data from desktop PCs as well as mobile platforms and provide real time visualization and analytics of all the available project data. Mobile apps provides the field operator and/or a machine operator with superb position awareness which can be used for verifying locate data and providing visual references as well as guiding excavation operations and monitoring equipment movement out in the field.

The portal permits the user to interface with the project site data sets and asset location information hosted on the ProStar Online servers. The location of one-call tickets, utility lines, and excavation activity is presented on the portal's web interface that is integrated with Google Maps as the ortho photography layer.

ProStar Online's visual display functionality is best illustrated through these graphic examples where a One Call Ticket Notice and subsequent practices have been fulfilled and the information digitally transmitted and recorded onto the portal for viewing. In the examples provided, a utility "locator" has been deployed in the field for marking a utility line with Tri-Global Mobile Utility Suite in response to the VUPS "One-Call Ticket" request and the heavy equipment operations were monitored using Trimble systems.

The One Call Ticket's proposed dig site area is plotted in the red polygon area. Current asset location data, equipment position as well as photo tags of the asset are readily accessible and readily viewed if they are available. The Google Satellite imagery feature has been selected.



Google Maps with satellite imagery layer for in the field visual referencing and zoom-in function have been selected to identify locate data relative to road and curb positioning.

Running on any major mobile ap with a browser and connectivity to the Portal, buried utility locations and attribute information is displayed. ProStar displays detected assets and distance relative to equipment position based upon the project site data and the system coordinate readings.

ProStar Online™ transforms operations into a real time project management system and can deliver critical information of asset locations throughout all phases of a project. With the ability to have instant access to critical location data and to make visual observations in order to verify project site data, all phases of the One Call Ticket, data locating and excavation practices are improved.

ProStar Online displays located assets featuring a street level view and provide the asset locate data as well as the Data's pedigree and precision meta data. ProStar visually displays the asset location point and all available attribute information to the locator for visual references and to equipment operator for improved dig or no dig decisions.

CONCLUSION

As a result of the GTI, VUPS and ProStar effort, a comprehensive solution that manages the full life cycle of utility asset data management was developed. The system is designed to dramatically reduce One Call Ticket Notifications and Heavy Equipment Encroachment by streamlining data processes, providing better information and improving the ability to make more informed key strategic decisions.

For decades now, there have been no standards for the management of utility asset data. The need for an improved and comprehensive solution has been well documented for years, but has remained impeded by the disjointed and reactive nature of the State One Call Centers, the inaccuracy of available utility data, the vague and unknown nature of the underground space and by the sheer number of stakeholders involved.

As our nation's utility infrastructure continues to rapidly expand from population growth, the underground space in which it lies is becoming increasingly overcrowded and what does actually lies beneath remains unknown with any level of confidence. With over 20 million excavations each year and a conflict occurring every 60 seconds, third party damage remains the greatest threat to underground utilities. Today, with new market drivers including regulatory change, technology shifts and change in risk assumption, stakeholders are under increasing pressure to provide an improved method to reduce the increasing number of damages and loss of life caused by ineffective data management and damage prevention practices.

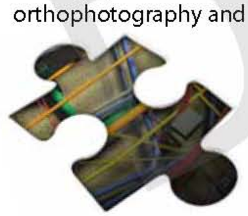
In summary, the VUPS Pilot Project demonstrated the feasibility of an advanced data management and damage prevention system. The project provided significant value, by creating the processes required for enhancing both the quality and efficiency of asset location data for all stakeholders and the business rules and protocols for excavation monitoring in order to prevent encroachment. Project developments and implementation also provided valuable insight that is being used to even further develop best practices and business cases for the discovery and adoption of new technologies moving forward.

ProStar Online now offers a low cost and easy to use solution to enable utilities to better manage their geospatial data and to improve all aspects of their business operations, including the collection, storage and distribution of asset location data. ProStar offers clients the ability to license the solution without substantial investment in technology or change in current business practice. The system is offered as an SAS or "service as a software" and offers clients the convenience to simply pay a subscription fee based on user access, consumption and storage requirements.

MOVING FORWARD

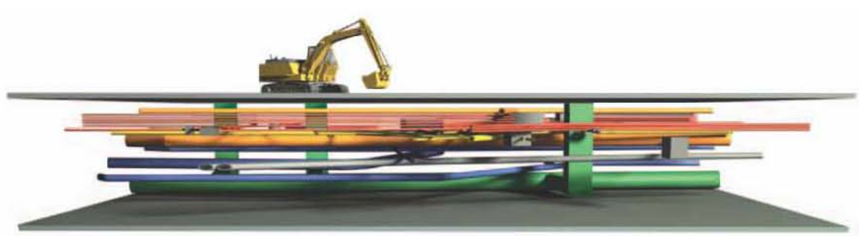
ProStar continues to make advancements in its technology and further enhance ProStar Online through key technologies including Google Earth as well as a strategic relationship with the University of Michigan.

Google Earth provides ProStar's clients access to an easy to use interface from both desktops and mobile apps that is familiar and popular to hundreds of millions of users. Moving ProStar Online on top of Google Earth opens an extensive and valuable basemap of imagery, roads, and other points of interest. Google Earth will enhance ProStar Online with massive amounts of existing Google data, including demographic information, emergency response information, as well as satellite orthophotography and 3D images of project site landscapes.



ProStar is also pursuing Augmented Reality Visualization for Knowledge-Based Excavator Control through a development partnership with University of Michigan. An Augmented Reality (AR) visualization will create a solution for improving the spatial awareness and decision-making capabilities during heavy equipment movement and operations by providing 3D display of utilities.

Collectively, these technologies are creating a new utility asset data management and data visualization technology that will allow field crews and equipment operators to visually identify precise utility line locations buried below the landscape's surface and relative to their position, thus helping to improve all phases of data collection and damage prevention practices.



Page 7

2011 CETI AWARD RECIPIENT

In April 2011, ProStar received a CETI Award for its ProStar Online™ in the category of Real-time Project and Facility Management, Coordination and Control. The Celebration of Engineering & Technology Innovation Award is given annually by FIATECH to organizations that have conducted new and emerging technology implementations as well as research and development. FIATECH, a member-led, industry consortium, provides global leadership in identifying and accelerating the development, demonstration and deployment of emerging and innovative technologies.

ISSUED U.S. PATENTS:

U.S. Patent 7,482,973 B2: Precision GPS Driven Utility Asset Management and Utility Damage Prevention System and Method.

A method and apparatus, including software, for the development and operational use of precise utility location and utility asset management information. Field-useable data sets may be produced that meet standards of accuracy and usability that are sufficient for use by field operations personnel participating in damage prevention activities associated with ground penetrating projects (e.g., excavating, trenching, boring, driving, and tunneling) or other asset applications. Some embodiments relate to integrating utility asset data including coordinate location, and geographical information data using a consistently available and accurate coordinates reference for collecting the data and for aligning the geographical information data. Some embodiments relate to managing projects with equipment that provides real time images and the updating of the data as required with this desired accuracy.

U.S. Patent 6,798,379: Method of Dynamically Tracking a Location of One or More Selected Utilities

A method of dynamically tracking a location of one or more selected utilities. A first step involves providing a portable controller having a memory. A global positioning system (GPS) co-ordinate device and a display are coupled to the controller. A second step involves storing in the memory of the controller a series of GPS co-ordinates for the one or more selected utilities within an assigned service area of a municipality. A third step involves using the GPS co-ordinate device to dynamically provide GPS co-ordinates to the controller as positioning of the GPS co-ordinate device changes. A fourth step involves using the display to display the GPS co-ordinates of the GPS co-ordinate device on a scrolling display of GPS co-ordinates, together with the series of GPS co-ordinates for the one or more selected utilities, such that the relative position of the GPS co-ordinate device to the one or more selected utilities is always known.

U.S. Patent 6,956,524: Method of Dynamically Tracking a Location of One or More Selected Utilities [Modification of 6,798,379]

A method of dynamically tracking a location of one or more selected utilities: A first step involves providing a portable controller having a memory. A global positioning system (GPS) co-ordinate device and a display are coupled to the controller. A second step involves storing in the memory of the controller a series of GPS co-ordinates for the one or more selected utilities within an assigned service area of a municipality. A third step involves using the GPS co-ordinate device to dynamically provide GPS co-ordinates to the controller as positioning of the GPS co-ordinate device changes. A fourth step involves using the display to display the GPS co-ordinates of the GPS co-ordinate device on a scrolling display of GPS co-ordinates, together with the

Page 8

series of GPS co-ordinates for the one or more selected utilities, such that the relative position of the GPS co-ordinate device to the one or more selected utilities is always known.

U.S. Patent 7,834,806: Systems and Method for Utility Asset Data Collection and Management

A system and method for collecting utility location information: The system and method includes identifying a current location; identifying an utility asset and a location of the identified utility asset in a predetermined project area including the current location; associating the current location with the identified utility asset; in real time, integrating an imagery of the project area with the current location and the location of the identified utility asset to generate an image representation of the project area; in real time, displaying the representation of the project area comprising the current location, a representation of the utility asset and the location of the identified utility asset; integrating the obtained location with the GIS landbase template including the map imagery and the infrastructure to create a precision grid including the location of the utility asset the map imagery and the infrastructure; storing the verified location of the identified utility asset and data about the type and material of the identified utility asset in a first database; and managing usage and distribution of the stored precision grid utilizing the defined project criteria, rules applied to the project and data accessibility rights.

U.S. Patent 7,978,129: System and Method for Collecting and Updating Geographical Data

A system and method for generating a GIS data transaction including information about the topography of a region and utilities within the region. The method and system include providing information about the topography of the region; receiving information about a user collecting data related to one or more utilities in the region; receiving information about time and date of the collected data; receiving information about each of the utilities; receiving information about location of each of the utilities; receiving information about the manner of collecting data; receiving information about revisions made to the information about the map; and integrating the received information with the information about the topography of the region into a GIS data transaction.

The GIS data transaction may be used to generate a precision integrated grid and the precision integrated grid may be used to identify and locate a utility in the region. The GIS data transaction may then be displayed with reference to imagery of the area in real time.

US Patent 7,920.068 : Distance Correction for Damage Prevention System

A system and method for determining a distance of a utility asset from moving equipment. The invention determines a first current location of the equipment; accesses stored coordinates for a plurality of utility assets; selects an area of interest including a portion of the plurality of utility assets; identifies local utility assets in the selected area; determines a utility asset nearest to the first current position of the equipment, from the local utility assets; determines velocity and direction of the moving equipment; and determines the distance from the nearest utility asset to the second current location of the equipment responsive to the determined velocity and direction of the equipment. The invention may then generate a warning indication responsive to the determined distance.

Appendix B – ExcaVision Brochure

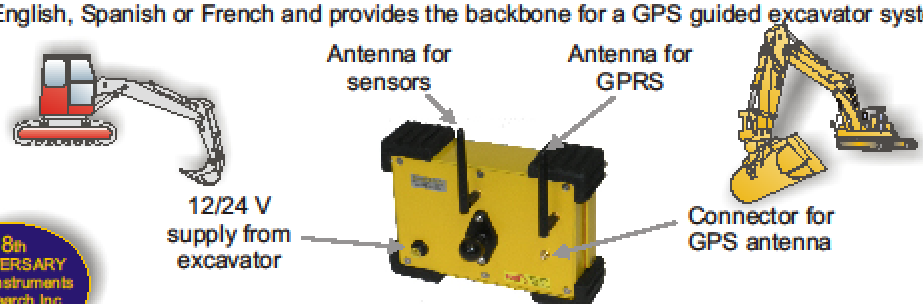
ExcaVision Systems

ExcaVision with built in automatic digging trigger

Excavator Grade Control System

For any size excavator or backhoe

The new ExcaVision WP combines the ExcaVision excavator depth monitor with a GPS and GPRS to provide a digging trigger for One-call centers and perfect digging without having to stop to measure. The system is waterproof and because the sensors are wireless, it can be installed very quickly on any size excavator. After initial installation and calibration, the system needs no attention for years. It can be moved from one machine to another in minutes and holds any number of excavators in memory. The screen can show the menus in English, Spanish or French and provides the backbone for a GPS guided excavator system.

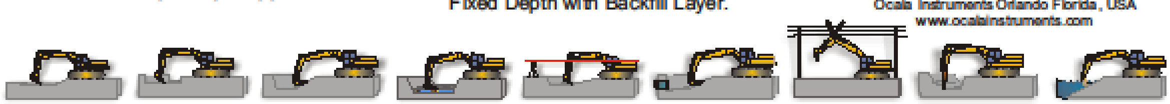


18th ANNIVERSARY
Ocala Instruments & Research Inc.
1992 to 2010

Please call for more info
1-800-344-4788 or
1-407-249-1450

APPLICATIONS: Footers, Basements, Foundations, Flat Bottom, Trenching, Simple Slope, Flat and simple slope, Ditch profile, Embankments, Canals and Batters, Fixed Depth with Backfill Layer.

Ocala INSTRUMENTS
Ocala Instruments Orlando Florida, USA
www.ocalainstruments.com



END OF REPORT