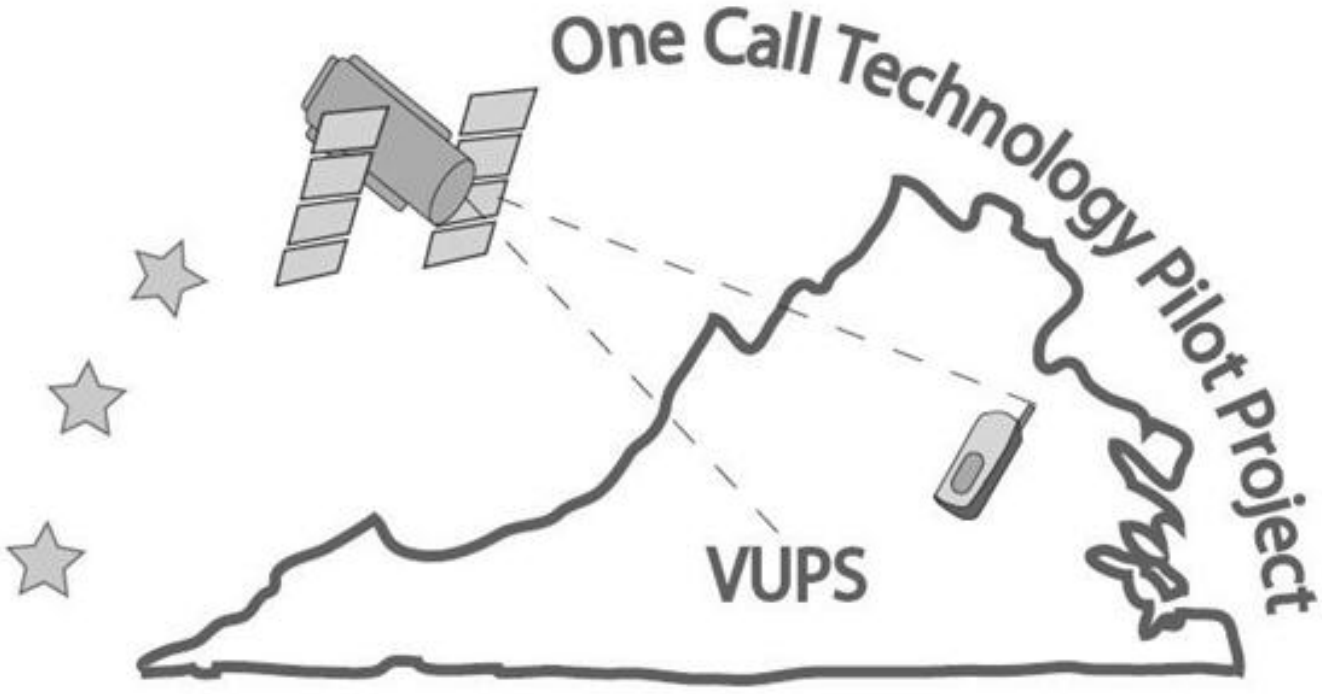
Virginia Pilot Project

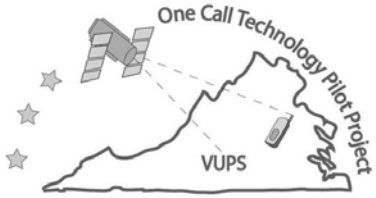
Incorporating GPS Technology to Enhance One-Call Damage Prevention



Phase I – Electronic White Lining

Project Report

November 2007



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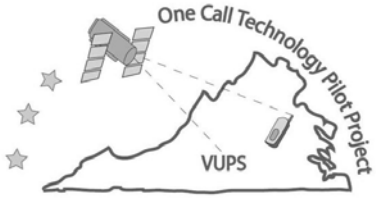
Note: The participation of the U. S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration and the Virginia State Corporation Commission in this project and the preparation of this report do not imply any endorsement of any product, service or enterprise associated with the project or the report.



Executive Summary

Excavation damage continues to be a leading cause of damage to underground facilities. It was cited as the cause in over 15% of all pipeline incidents in 2006. Effective damage prevention programs are necessary to prevent damages to underground facilities and to ensure public health and safety, environmental protection and continuity of vital services. All stakeholders, including the public, share responsibility for and the benefits of damage prevention. Although much has been done to address excavation damage it continues to be a problem.

Central to all damage prevention efforts is effective communication of accurate and timely information among stakeholders. All states have damage prevention laws that require communication among excavators, one-call centers and underground facility operators before digging can take place. The purpose of that communication is to notify the operators to identify and visibly mark the location of their underground facilities before the excavation begins. This allows the excavator to avoid damaging underground facilities during excavation.

In 2005, PHMSA[1] along with PRCI, VA SCC, VUPS, CGA and other key stakeholders initiated a pilot project to enhance the one-call damage prevention process through the use of GPS technology. Appreciation is extended to all of those stakeholders that have participated in the formulation and implementation of the Pilot Project. Their collaboration, cooperation and collective efforts have made Phase I of the Project and this report possible. (See Appendix C for a list of participants.)

Key Results from Pilot Project

Several key statistics are reflected in the data generated by the Pilot Project. The results indicate significant improvements in the costs and efficiencies related to implementing one-call damage prevention programs. These in turn should lead to improvements in the benefits of such programs to all stakeholders and to significant improvements in underground facility safety.

- The number of locate notification tickets issued was reduced by 8.04%.
- The average notification area for locate requests was reduced by 89.42%.
- 3-hour notices were reduced by 56.78%.
- Cancelled locate requests were reduced by 36.51%.
- The need for extended marking schedules was reduced by 66.22%.

[1] PHMSA (US Department of Transportation's Pipeline and Hazardous Materials Safety Administration); PRCI (Pipeline Research Council International); VA SCC (Virginia State Corporation Commission); VUPS (Virginia Utility Protection Service); CGA (Common Ground Alliance)

- Incorrect address tickets were reduced by 32.60%.
- Tickets with unclear marking instructions were reduced by 91.80%, and
- No ticket with the scope of the excavation larger than allowed by Virginia law was submitted by excavators using the Pilot technology.

The above data proves the Pilot Project provided a more efficient locate request process, ensuring that locate requests were processed in a more timely and accurate manner.

The bottom line is that the application of GPS-enhanced electronic white-lining technology to the one-call damage prevention process has been demonstrated through this Pilot Project to benefit the damage prevention process.

Benefits

The Stakeholder Benefits Table shown in Appendix E reflects the benefits to the various stakeholders from improvements in damage prevention achieved from applying GPS technology and electronic white-lining. However, every stakeholder benefits at least indirectly from each and every benefit accrued to individual stakeholder groups. The universal benefits come from improved safety and reliability of vital underground infrastructure. Preventing incidents that can cause serious injury and even death is paramount. Preventing outages of vital energy pipelines, electric services, telecommunications networks, and water supplies is extremely important. Improving the damage prevention process through the application of technology is proved to work.

Project Design

Virginia was chosen as the location for the Pilot Project through the active participation of key stakeholders. Virginia is recognized for its pipeline safety leadership, existing damage prevention laws and active enforcement processes. From 1996 through 2006 excavation damages to gas distribution pipelines in Virginia were reduced by more than 50 percent. Additionally, coincident with the implementation of the Pilot Project, VUPS developed and implemented enhanced mapping capabilities that enabled the Pilot Project to be conducted.

Phase I of the Virginia Pilot Project focused on the application of global positioning system (GPS) technology to improve the locational accuracy of locate requests submitted by the excavators to the VUPS one-call center. The emphasis was on the development and use of enhanced electronic white-lining[2] through the use of GPS technology and enhanced one-call processes. The Project Team utilized

2 "White-lining" is the term used for the excavator's delineation of an excavation area through the painting of white lines on the ground. Electronic white-lining involves the delineation of the excavation area through the use of GPS and electronic mapping technology.

existing cell phone, Internet and GPS receiver technologies combined with the development of specific software applications and enhanced one-call processes.

The primary goal of Phase I was to reduce the rate of over-notification[3] by improving the quality and accuracy of locate notification tickets. The number of locate notification tickets issued to underground facility operators in the U. S. is conservatively estimated to exceed 150 million per year. Over-notification can affect from 40% to 60% of the total number of tickets issued for some types of utilities and has a very significant impact on stakeholder resources and the efficacy of the one-call process. Contributing to over-notification are vague and incorrect excavation site descriptions on locate requests submitted to the one-call center. Improving on the locational accuracy of locate requests and on the efficient communication of data was considered paramount to reducing over-notification.

Further work is planned for the Virginia Pilot Project. Phase II will involve the application of GPS technology to locating instruments and the development of electronic locator manifests. Phase III will involve the integration of GPS and mapping technology on excavating equipment.

Data Analysis

Fairfax County, Virginia, was used as the test area for locate requests generated in Phase I. Control data was established for comparison from non-Project related locate requests generated in Fairfax County. Fairfax County was used for both the test and the control area to maintain a consistent saturation of utilities throughout the project. During the Pilot Project VUPS processed a total of 88,187 locate request tickets in control data and a total of 2,005 tickets in test data.

The primary target metric was a reduction in the rate of over-notification. The number of utilities notified per locate request was evaluated for both the control and test data. The control data averaged 7.96 member notifications per locate request. The test data averaged 7.32 member notifications per locate request. This demonstrates an 8.04% reduction in the number of tickets issued per locate request.

Based on a total 2006 VUPS annual ticket transmission count of 7.8 million tickets and an estimated average locate cost of $10 per ticket, an 8.04% reduction could conservatively result in a net savings of $6,271,200 across Virginia in locate costs alone.

This statistic is considered even more significant when extrapolated to a much broader basis. It is conservatively estimated that the total annual number of notification tickets issued to facility operators in the U. S. could easily exceed 150 million. Using 150 million tickets per year as the basis, applying an estimated

[3] "Over-notification" is the term used to describe the excess locate notification tickets issued to facility operators for excavation locations where the operators don't actually have installed facilities or would not have been notified had the dig site on the ticket been more specifically defined.

average locate cost of $10 per ticket, and extrapolating the demonstrated 8.04% reduction in outgoing notification tickets nationwide, the potential savings in locate costs alone could exceed $120 million.

An additional measurement for the impact of the Pilot technology on the issue of over-notification is analysis of the average polygon size for locate requests. The average polygon size for the control data was 768,527 ft^2, whereas the average polygon size for the test data was 81,341 ft^2. This represents a relative 89.42% reduction in the average notification area for locate requests.

This significant reduction in the average size of notification areas has additional potential benefits for the stakeholders. Obviously, locating and marking a smaller area should require somewhat less time to accomplish. For the excavator, this means that the excavator might not have to wait as long for a ticket to be cleared so that excavation can begin. It also means less exposure time to locating crews, thus improving personnel safety. As smaller, more accurate areas are identified for excavation, it is less likely that existing underground facilities will be affected; that is, fewer facilities will be affected within these smaller defined areas. Facility operators will benefit as fewer tickets will have to be screened and locator resources are less likely to be deployed to locations where the operators don't actually have existing facilities in the ground. This will allow limited resources, including locators, to be focused more efficiently on other aspects of damage prevention, including improvements in locate accuracy. More accurate locates will reduce the risks of excavation damages and subsequently, reduce the risks to employees and the public.

Obviously, as in the reduction in outgoing notification ticket numbers, if extrapolated more broadly across the state of Virginia and, indeed, nationwide, the benefits resulting from the significant reduction in the average notification area for locate requests would multiply exponentially.

It should be noted that several utility operators within Fairfax County have registered the entire county, including all cities within the county, for notification of locate requests. Therefore, regardless of the size of an original locate request, these operators will still receive a notification. Even greater savings could be achieved through tighter, more precise facility registration by utility operators.

The analysis of other data points collected during the Pilot period also showed significant efficiencies gained. For example, the number of "3-hour" notices called by excavators using the pilot technology was reduced by more than 56%. In Virginia the 3-hour notice is used to notify an operator when an excavator identifies clear evidence of that operator's unmarked facility. The reduction in 3-hour notices could translate to cost savings ranging between $2.9 million and $8.7 million in Virginia, relative to excavators' reduced wait times for locate marks.

Excavator Feedback

During Phase I, 25 users from 11 companies submitted locate requests using the Pilot Project technology (equipment and processes). Of course, this is representative but a very small portion of the statewide excavator population. Individual users submitted from 1 to 987 tickets. The number of tickets submitted by individual companies ranged from 4 to over 1,600.

Feedback was solicited from the participating excavators regarding the enhanced one-call process and the equipment being used. Some of the key messages received from the excavators include:

- Excavators benefited significantly from application of the Pilot Project technology. Submission of locate requests by excavators in the field translates to improvements in ticket accuracy and quality and overall process efficiencies. Improved process efficiencies result in reduced wait and down time for the excavator. It also allows for improved internal administrative efficiencies. Improved ticket quality reduces the number of call backs from the locators for more information.
- Excavators were unanimous in expressing their interest in expanding implementation of the technology to other geographical areas where they are performing excavations.
- The equipment and processes should be made as simple as possible for ease of use. In fact, a device dedicated to gathering GPS coordinates and electronically submitting locate request tickets might be preferable to a multi-purpose device adapted to this use. However, equipment characteristics such as size, functionality, durability and ruggedness, and battery life are important considerations. Additionally, a user support/help desk is a necessity.
- Future enhancements to the technology could include integration with excavator work management systems. Additionally, the technology could accommodate other types of tickets such as 3-hour requests, re-marks and updates. Excavators could be provided with the ability to view positive response information on the handheld equipment. Excavators could also be provided the ability to view and print ortho-photographic maps with the facility locate lines overlaid (i.e., Phase II).

Conclusions & Recommendations

This project demonstrated that the application of GPS technology in electronic white-lining can be of significant benefit to the one call process. The reduction in the number of outgoing notification tickets is considered significant and should result in significant savings in locate costs if applied throughout Virginia. If applied across the nation it could result in savings of over $120 million. Perhaps more significant is the reduction in average polygon size. This has tangible benefits to all stakeholders and can result in significant cost reductions and improvements in

safety. Likewise, the improvements demonstrated in process efficiencies will result in cost savings, improved locate accuracy, and improved safety.

It is recommended that the CGA consider this application of technology as a Damage Prevention Best Practice. It is also recommended that other one-call centers consider the development and use of this technology. In support of this recommendation, the directors of VUPS and Arizona Blue Stake have offered to be available for consultation and assistance.

The level of accuracy when implementing the Pilot Process will be directly dependent on the level of accuracy of the one-call center's base maps. And, although not required, ortho-photographic maps are an excellent enhancement.

There are certain basic requirements that must be met to enable implementation of this technology for other one-call processes. These include:

- Develop the software for the use of the technology through the individual one-call center application provider.
- Develop and adopt the use of polygons for locate request ticket entry and utility operator facility notification area registration.
- Create and implement a centralized help desk to rapidly respond to any process issues.
- Develop training programs and provide adequate personnel to train stakeholders.

The Path Forward

A bilateral approach will be utilized to promote the benefits of electronic white-lining demonstrated in the Virginia Pilot Program. This will include promoting the benefits to all stakeholders through a nationwide public awareness campaign while concurrently promoting and marketing further implementation of the established process within Virginia.

The results from the Virginia Pilot Project will be submitted to the CGA for consideration in the development of damage prevention best practices. The CGA Best Practices are used throughout the industry as guidelines for damage prevention performance.

The technology and processes demonstrated in the Virginia Pilot Project will also be promoted among the various one-call software providers. Currently any Norfield Data Products users will require only slight modification to the one-call software that has already been developed and is in use. IRTH Solutions has begun to develop compatibility with the Virginia Pilot Program process. Between these two one-call software vendors, enhanced electronic white lining as demonstrated in this Pilot Project could be readily developed in a number of states. Obviously, other call centers are encouraged to develop similar software applications to allow the use of the Pilot Project technology.

Phases II and III of the Pilot Project have been discussed by the participating stakeholders as further developments that could increase impact to multiple stakeholders in the one-call process.

Phase II would involve the application of GPS technology to locating instruments and the development of electronic manifests of the locator's activity. It is envisioned that the utility markings would be overlaid onto the ortho-photographic maps to provide a bird's eye view of the excavation site. This will also improve the detail currently seen in some manifest records. Excavators have indicated they would benefit from having access to the electronic manifests. Utility operators could use the data from Phase II as a verification of their own maps and records.

Phase III would involve the integration of GPS and mapping technology on excavating equipment.

Background

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 hundreds of thousands of miles of telecommunications networks, electric power distribution systems, water and sewer systems and other utilities that all Americans depend on day-to-day.

Utility Damage by Excavation

Underground facilities are vulnerable to damage that can result during excavation activities conducted near the facilities. Excavation is defined[4] as any operation using non-mechanical or mechanical equipment or explosives in the movement of earth, rock or other material below existing grade. Excavation may be accomplished by various methods.[5] 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 just to energy pipeline systems (hazardous liquid and natural gas), nationwide from 1997 through 2006.

Preventing Utility Damage by Excavation

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[6].

Key to the effectiveness of damage prevention programs is effective 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 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 will allow 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.

[4] Common Ground Alliance (CGA): Best Practices Report, Appendix A: Glossary of Terms/Definitions. Version 4.0, March 2007. www.commongroundalliance.com.
[5] Excavation may include but is not limited to: augering, blasting, boring, digging, ditching, dredging, drilling, driving-in, grading, plowing-in, pulling-in, ripping, scraping, trenching, and tunnelling.
[6] CGA Best Practices Report.

Table 1

Pipeline Incidents Resulting From Excavation Damage

Reporting Year	Number of Incidents	% total Incidents	Fatalities	Injuries	Property Damage	% of Total Property Damage
1997	72	26.9%	6	22	$27,098,468	29.2%
1998	87	29.4%	14	38	$47,026,181	32.0%
1999	76	27.6%	17	33	$35,801,194	23.9%
2000	81	27.9%	7	25	$37,947,107	14.9%
2001	80	34.3%	3	21	$28,733,141	43.2%
2002	55	21.3%	3	9	$16,390,449	14.6%
2003	81	27.4%	5	39	$21,105,168	15.9%
2004	67	20.4%	6	10	$21,389,999	7.9%
2005	46	12.8%	2	10	$15,236,888	1.4%
2006	40	15.5%	6	10	$9,003,057	7.5%
10-Year Totals	685	24.0%	69	217	$259,732,652	11.5%

Source: PHMSA Significant Incidents Files October 19, 2007, includes all excavation damages.

An excavator may be a homeowner, landscape contractor, site developer, utility contractor or anyone else proposing to excavate or engaging in excavation or demolition work. Often the underground facility owner/operator is the excavator and, as such, must follow the same one-call process as third-party excavators to ensure the protection of its own underground facilities and of facilities operated by others.

One-call centers facilitate the necessary and effective communication of information in the damage prevention process. One-call centers maintain maps of notification areas, receive locate request information from excavators planning excavations, and issue locate notification tickets to member facility owners/operators so they can locate and mark their facilities in the excavation areas. In some states, the locator is required to provide a positive response that facilities have been located and marked or that marking is not necessary, and that information is made available to the excavator. In some other states, like Virginia, the one-call center is required to forward the positive response information to the excavator.

Professional locators determine and mark the specific location of underground facilities in the areas of proposed excavations. The locator may be an employee of the facility owner/operator or may work for a third-party locating company under contract to the owner/operator. It is important that the locator be able to accurately determine the correct location of the planned excavation, determine if the owner/operator has underground facilities that could be affected by the excavation and, if so, accurately locate and mark the location of those facilities to help ensure they are not damaged during the excavation process.

Underground facility damage prevention requires effective communication of accurate and timely information among several stakeholders, including the excavator, the one-call center, the facility owner/operator and the locator. If this communication can be made more effective and efficient, the damage prevention process can be improved and public health and safety, environmental protection and the integrity of vital underground infrastructures can be better assured.

All states have damage prevention laws that require excavators to contact their one-call center prior to beginning the excavation. To facilitate meeting those requirements, the Federal Communications Commission (FCC) has mandated the use of "811" as a national call-before-you-dig 3-digit telephone number. Use of the 811 number will facilitate the connection of anyone intending to dig with their respective one-call center. Although the implementation of "811" will facilitate excavators calling to request facility locates, the integration of advancements in technology as demonstrated in the Virginia Pilot Project can significantly enhance the communication of accurate and timely information among stakeholders involved in the one-call process.

Introduction

The Virginia Pilot Project for Incorporating GPS Technology to Enhance One-Call Damage Prevention was undertaken as a 'proof-of-concept' project to research and implement new and existing technology to significantly enhance the development and communication of accurate information among stakeholders regarding the exact location of planned excavations. Resulting improvements in the one-call damage prevention process would in turn have a positive impact on damage prevention and the safety and reliability of operations of underground facilities.

The primary focus of Phase I (Electronic White Lining) of the Pilot Project was the incorporation of global positioning system (GPS) coordinates in facility locate requests submitted by excavators. In addition it involved the conveyance of those GPS coordinates and other data through electronic data exchange instead of through the use of traditional telephone voice communication methods.

Existing hardware technology coupled with specifically developed software applications was used for determining the GPS coordinates of proposed excavation sites. This data was communicated via wireless and web-based technology to the one-call center. Hardware-specific software applications were developed to link the various components together. Existing one-call system processes were modified to ensure the enhanced location data was captured and communicated.

Project Metrics

One of the key metrics for Phase I of the Pilot Project was the rate of outgoing locate notification tickets issued per incoming locate request. Assuming the conservative rate of 6 outgoing locate notification tickets generated for each incoming locate request, the total number of locate notification tickets issued to underground facility owners/operators could easily approach or exceed 150 million per year in the United States. It was postulated that improving the accuracy of the excavation location reported on excavator locate requests would improve (reduce) this ratio.

Within that metric is a subset of locate notification tickets that are considered unnecessary since the facility owners/operators receiving the tickets do not actually have facilities in the associated excavation areas or would not have been notified had the dig site on the ticket been more specifically defined. That subset of unnecessary tickets represents a condition known as "over-notification." Depending upon the nature of the operator's facilities, over-notification can affect from 40% to 60% of the total locate notification tickets issued.

Facility owners/operators pay for each ticket received from the one-call center and in most cases dispatch locator crews to verify the location or absence of their facilities in the excavation area. Thus, over-notification can be very costly and presents inefficient and ineffective use of locating resources that could otherwise be used to perform needed locates more effectively. Improving the ability to

accurately determine and map the excavation location based GPS coordinates, along with the use of improvements in mapping technology, was expected to reduce the rate of over-notification. (See Appendix A for further discussion on over-notification as it relates to the Pilot Project.)

Benefits to Stakeholders

The Stakeholder Benefits Table shown in Appendix E reflects the benefits to the various stakeholders from improvements in damage prevention achieved from applying GPS technology and electronic white-lining. However, every stakeholder benefits at least indirectly from each and every benefit accrued to individual stakeholder groups. The universal benefits come from improved safety and reliability of the nation's vital underground infrastructure. Preventing incidents that can cause serious injury and even death is paramount. Preventing outages of vital energy pipelines, electric services, telecommunications networks, and water supplies is extremely important.

Overall benefits from application of the technology tested in this Pilot Project include:

- Significantly improving the efficiency and accuracy of excavation and facility location information communicated between excavators and owners/operators of underground facilities; thereby
- Improving the reliability and safety of the nation's underground facility infrastructure.

The Project Team considered benefits for each specific stakeholder segment. To provide these benefits, it was determined that the enhanced one-call process must be effective and usable by affected parties without the need for extensive training, prohibitively expensive equipment or negative impacts on existing work processes. Stakeholder benefits include:

Public

- Reduced threats to public safety and the environment.
- Reduced outages of vital services resulting from damaged facilities.

Excavation Contractors

- Reduced time from submission of a locate request to being cleared to work.
- Reduced risk of damage incidents involving injuries to employees or the public.
- Reduced risk of damage to equipment and existing infrastructure.
- Reduced risk of downtime, enforcement actions and litigation resulting from damage incidents.

One-call Centers

- Enhanced one-call damage prevention processes achieved by reductions in the time required to process locate requests, the inclusion of GPS reference points coupled with digitized high-definition base maps, and automation of input and output data through the use of standard web-entry formats and software.
- Improvements in the accuracy of the locate ticket information.
- Improved quality of service resulting from more timely and accurate data and reduced over-notifications for member utilities.

Locators

- Improvements in the rates of over-notifications and incorrect tickets. GPS reference points will help locators assure they are in the correct geographic location to perform the facility locate.
- Reductions in the locate area footprint and improvements in the rate of clearing tickets without the need for field locates will allow locators additional time to perform more locates and improve locate accuracy.
- Improve personnel safety by allocating more time to perform locates.
- Improve locate accuracy by allocating more time to perform locates.

Underground Utility Owners/Operators

- Reductions in over-notification will allow limited resources to be focused on other aspects of damage prevention.
- Reduced damage prevention program costs incurred by unnecessarily deploying locator resources when they are not required.
- Increase locate accuracy through more efficient use of resources.
- Provide the same benefits as for excavators, including:
    - Reduced time from submission of a locate request to being cleared to work.
    - Reduced risk of damage incidents involving injuries to employees or the public.
    - Reduced risk of damage to equipment and existing infrastructure.
    - Reduced risk of downtime, enforcement actions and litigation resulting from damage incidents.

Project Development and Implementation

Project Team

Phase I of the Virginia Pilot Project was developed and conducted by a Project Team composed of damage prevention stakeholders from various industries and agencies. These included representatives of hazardous liquid and gas transmission pipeline operators, local natural gas distribution system operators, electrical power companies, telecommunication companies, one-call system operators, excavators, locators and the Common Ground Alliance (CGA). The Project Team also included representatives from both federal and state regulatory agencies.

The Pilot Project kick-off meeting, held on May 26, 2005, was a call for a collaborative effort to enhance the damage prevention process. Many subsequent meetings were conducted to shape and implement the Project and a smaller project team was selected to promote a more effective process while maintaining representation of the affected stakeholder groups.

Virginia as the Pilot State

Virginia was chosen as the location for the Pilot Project through the active participation of some of the key stakeholders. Additionally, coincident with the implementation of the Pilot Project, Virginia Utility Protection Service (VUPS) developed and implemented enhanced mapping capabilities that enabled the Pilot Project to be conducted. Virginia was also chosen through recognition of its pipeline safety leadership, existing damage prevention laws and active enforcement processes.

In Virginia, intrastate natural gas utilities are required to report all damages and probable violations to the State Corporation Commission (SCC). These reports are thoroughly investigated. The facts regarding reported damages are evaluated, the root causes are determined and the information is captured in a single database. The results are reviewed by an appointed Committee and penalties may be assessed on the parties responsible for damage incidents. As a result of its damage prevention program, over the period from 1996 through 2006, excavation damages to gas distribution pipelines in Virginia were reduced by more than 50 percent. (See Figure 1)

Virginia's one-call center operator, VUPS, captures and maintains a large number of data elements relative to its operation, including locate requests and types of excavation activities, utility marking status and other aspects of the one-call process. The data is continuously reviewed and analyzed to evaluate the one-call program and to take appropriate actions to further reduce damage to underground facilities.

Coincident with Phase I of the Pilot Project, VUPS upgraded its one-call system software. VUPS converted from the use of grids to the use of user-defined polygons to define excavation locations on base maps. (Figures 6 and 7 illustrate the comparison of grids versus user-defined polygons.) . This mapping technology upgrade by itself was expected to result in more accurate depictions of the excavation areas for locate requests. Concurrently, VUPS was also migrating from the use of base maps that were based on Enhanced Tiger Files to base maps that incorporate the use of ortho-photographic enhanced digital overlays. These enhancements serve to illustrate that Virginia is on the leading edge in the use of technology to enhance the one-call process.

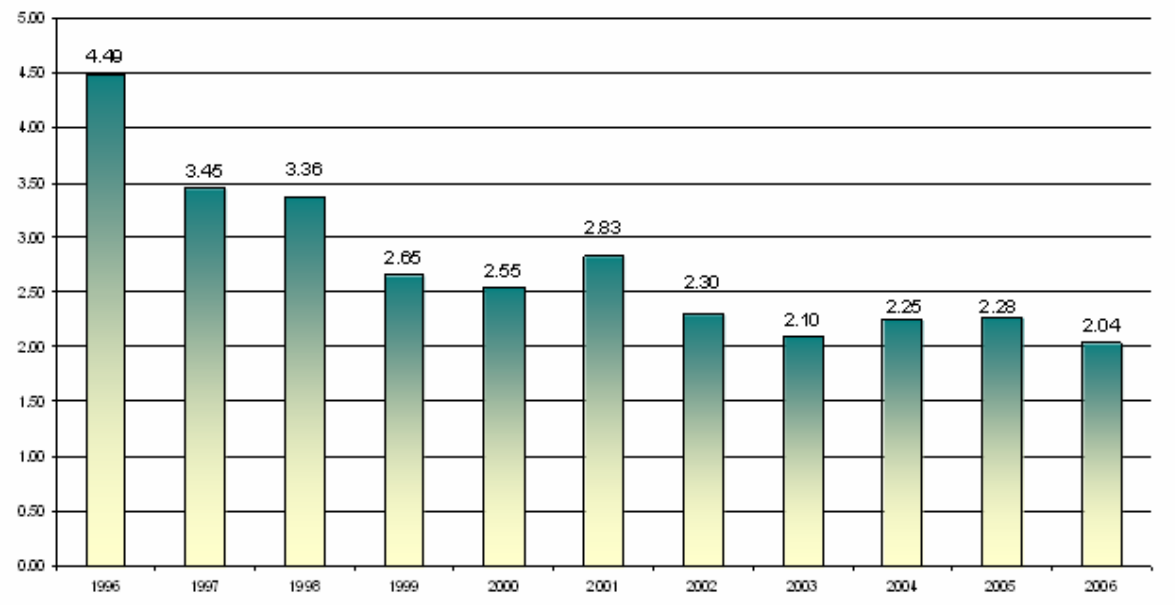


Figure 1: Virginia Gas Distribution Excavation Damages per 1000 Tickets

Due to the maturity of Virginia's program, the availability of historical performance data, and a formal process to investigate damages and determine root causes, Virginia was considered an appropriate place for the Pilot Project to identify current technologies to be refined or new ones to be developed to further improve the communication between excavators and operators.

Appendix B depicts the process used to gather and communicate GPS data in the enhanced one-call process implemented in support of the Pilot Project.

Geographic Test Area

When choosing the test area for Phase I of the Pilot Project, characteristics such as ticket volumes, GPS coverage, rural and urban settings, presence of

underground facilities and the availability of accurate historical data were considered. Since the field implementation phase of the project was to be relatively short, the area selected needed to produce adequate test data to accurately measure project performance.

Fairfax County, VA, was chosen as the test area. Fairfax County embodies both urban and rural areas. It includes the cities of Falls Church, Reston, Tysons Corner, McLean, Great Falls, Fairfax, Oakton, Springfield, Burke, Annandale, Chantilly, Centreville and Clifton. It is the most populous jurisdiction in both Virginia and the Washington metropolitan area. It is a thriving county and offered a relatively high level of excavation activity and several of the Pilot Project participants were performing excavation work in the County; thus, it offered adequate ticket counts for data analysis. Fairfax County was used for both the test and the control area to maintain a consistent saturation of utilities throughout the project Control data was established from non-Project related locate requests for comparison.

Vendor Technology Selection and Support

The Project Team issued a Request for Information (RFI) to solicit both existing and near-term solutions, approaches and technologies in support of Phase I of the Pilot Project. The RFI was sent to an extensive list of companies considered likely to have interest in supporting the project.

Information provided by several companies in response to the RFI proposed a range of solutions based on several different technologies that could be incorporated. The primary differences in the technologies were the purported accuracies of the GPS coordinates that could be obtained and the processes used to communicate those coordinates to the VUPS One-call Center. Depending on the equipment used, purported GPS coordinate accuracies ranged from 3-10 meters down to sub-meter.

A more precise (e.g., sub-meter) accuracy was discussed by the Project Team and was originally thought to be desirable, at least for comparative purposes. However, sub-meter accurate devices cost significantly more and have constraining variables associated with their use. For example, GPS satellite positions vary for different times of day and affect the ability to obtain sub-meter readings. Also, the user may have to be on station for a longer period of time to get the greater accuracy. Those factors, combined with the reality that one-call centers and facility operators usually add buffers to any notification areas, led the Project Team to conclude that pinpoint accuracy was not necessary or feasible for this Pilot Project.

Following a review of submitted information and presentations, the Project Team selected vendors to support Phase I of the Pilot Project. Cost and ease of use were two of the factors considered in the selection process. The selected vendors

were Sprint-Nextel, Vettro Corporation, Trimble Navigation and Norfield Data Products.

The Sprint-Nextel solution, in conjunction with software applications developed by Vettro Corporation and Norfield Data Products, utilized GPS-enabled cell phones to obtain GPS coordinates and create locate request tickets. This approach provided purported GPS accuracy in the 3-10 meter range. Sprint-Nextel was the only proposing vendor with cell phones already widely in use that had an internal GPS unit with the capability to display the latitude/longitude coordinates on the user screen. Sprint-Nextel already had other applications supporting other industries that utilized these capabilities.

A second approach was provided through the use of Trimble Navigation GPS receivers coupled via Bluetooth technology with Sprint-Nextel smart phones utilizing Windows Mobile 5.0 software. These were supported by remote ticket entry software developed for VUPS by Norfield Data Products. The Trimble receivers purported GPS accuracies in the 1-5 meter range.

Project Funding

Funding for Phase I of the Pilot Project was provided through a grant made to the Common Ground Alliance by the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) and through funding provided by the Pipeline Research Council International (PRCI). Direct funding expenditures for the Project exceeded $225,000. These funds were used for the development of software applications and the procurement of the hand-held devices and subscription services.

In-kind contributions of personnel time and direct travel costs were made by the various Project Team participants and their respective companies. Additionally, in-kind contributions were made by the participating excavators that put the Pilot Project technology and processes to use in the field. (See Appendix C for a listing of participants.)

Excavator Participants

A list of excavators, including underground facility operators, to potentially participate in Phase I of the Pilot Project was developed by the Project Team from data provided by VUPS. The data included the number of locate request tickets called in to VUPS by the excavators and where the operators' facilities were located relative to the geographic areas selected. The excavators and operators were ranked and the Project Team selected a short list of those determined most likely to participate and support the goals of the Project. Candidates were contacted by Project Team members to determine the final list of participants. The list of candidate contractors was expanded and revised to accommodate project needs.

During Phase I of the Project 25 users from 11 companies submitted locate requests using the Project technology (equipment and processes). This included companies involved in: landscaping, fencing, installing fiber optic lines, site development, pipeline construction and general construction. Of course, this is representative of but a very small portion of the statewide excavator population in Virginia. Equipment and training in support of the Project were provided to users in those companies.

Project Timeline and Milestones

Phase I of the Pilot Project consisted of: Project Development; Field Implementation and Data Gathering; and Data Analyses/Results Evaluation. Project development included vendor selection, the acquisition of equipment and the development of necessary software applications. A list of key target milestones was identified and a timeline was developed (see Figure 2). The timeline was revised as necessary to accommodate delays in reaching some of the target milestones and to accommodate seasonal weather influences during the data gathering phase.

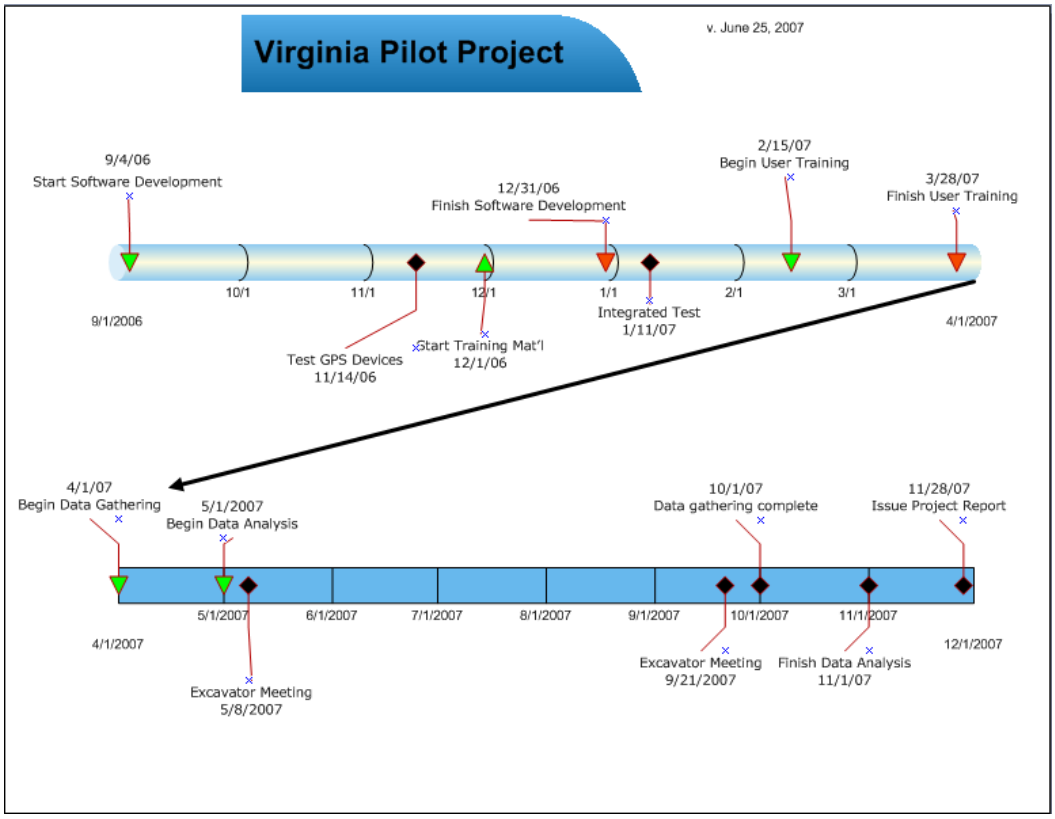


Figure 2: VA Pilot Project Timeline

Data Analysis

As previously discussed, Fairfax County, Virginia, was used as the test area for locate requests generated in support of Phase I of the Project. Control data was established from non-Project related locate requests generated in Fairfax County for comparison. Fairfax County was used for both the test and the control area to maintain a consistent saturation of utilities throughout the project. During the Pilot Project VUPS processed a total of 88,187 locate request tickets in control data in Fairfax County and a total of 2,005 tickets in test data.[7]

The primary target metric was a reduction in the rate of over-notification. The number of utilities notified per locate request was evaluated for both the control and test data. The control data averaged 7.96 member notifications per locate request. The test data averaged 7.32 member notifications per locate request. This demonstrates an 8.04% reduction in the number of tickets issued per locate request.

Based on a total 2006 VUPS annual ticket transmission count of 7.8 million tickets and an estimated average locate cost of $10 per ticket, that 8.04% reduction could conservatively result in a net savings of $6,271,200 across Virginia in locate costs alone.

This statistic is considered even more significant when extrapolated to a much broader basis. For example, the CGA One Call Systems International (OCSI) 2006 statistical data from 25 state one-call centers[8] showed a total of over 19 million incoming locate requests to those one-call centers. Conservatively, it can be assumed that the annual total number of incoming locate requests to one-call centers nationwide in the United States could exceed 25 million per year. Assuming a conservative rate of 6 outgoing locate tickets generated for each incoming locate request, the total number of notification tickets issued to facility operators could easily exceed 150 million per year. Using 150 million tickets per year as the basis, applying an estimated average locate cost of $10 per ticket, and extrapolating the demonstrated 8.04% reduction in outgoing notification tickets nationwide, the potential savings in locate costs alone could exceed $120 million.

An additional measurement for the impact of the Pilot Project technology on the issue of over-notification is analysis of the average polygon size for locate requests. The average polygon size for the control data was 768,527 ft^2, whereas the average polygon size for the test data was 81,341 ft^2. This represents a relative 89.42% reduction in the average notification area for locate requests.

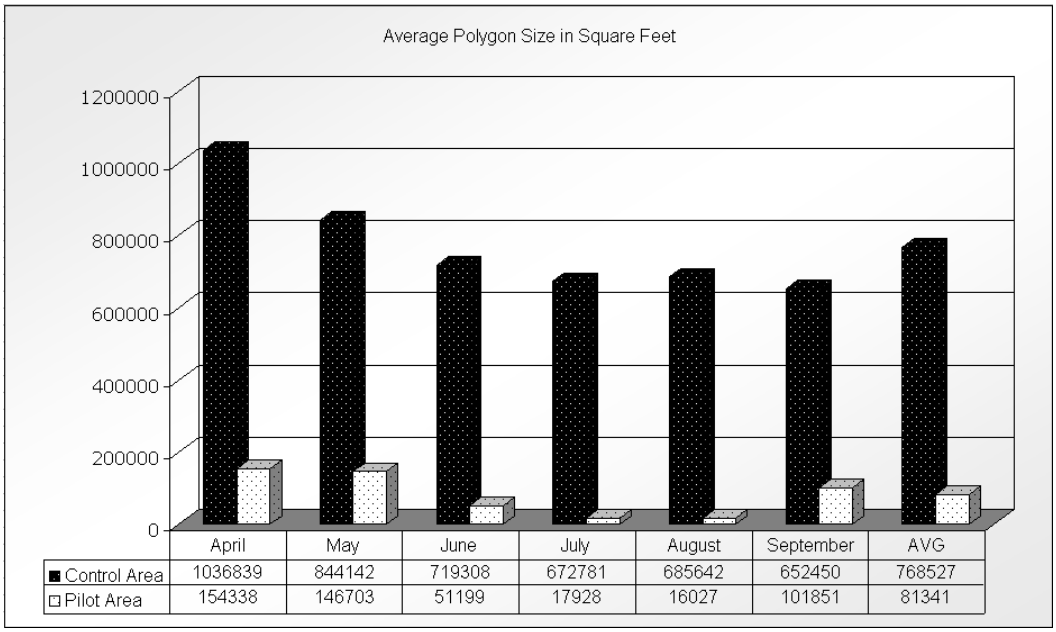
[7] Ticket data from the Pocket PC application was sparse; therefore it has not been included in the overall data analysis. The reason determined for the lack of tickets submitted via the Pocket PC equipment is that the excavators using that equipment simply were not doing much work going in the test area of Fairfax County. This appeared to be a factor of chance and did not appear to be the result of the usability or functionality of the equipment or software application.

[8] Alabama, Arizona, California, Colorado, Delaware, Florida, Georgia, Hawaii, Indiana, Kentucky, Maryland, Michigan, Montana, Nevada, New York, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas (1 of 3), Utah, Virginia, Washington (1 of 3), Wisconsin and Wyoming

This data is shown graphically in Figure 3. Figure 4 demonstrates the relative reduction in average notification area overlaid on an ortho-photograph. In Figure 3 the average polygon size for the Pilot test area appears to have increased in September; however, this is considered to result from the reduced number of locate request tickets that factored into the average polygon size.

This significant reduction in the average size of notification areas has additional potential benefits for the stakeholders. Obviously, locating and marking a smaller area should require somewhat less time to accomplish. This means that the excavator might not have to wait as long for a ticket to be cleared so that excavation can begin. It also means less exposure time to locating crews, thus improving personnel safety and affording more time to perform accurate locates. As smaller, more accurate areas are identified for excavation, it is less likely that existing underground facilities will be affected or more likely that fewer facilities will be affected.

Facility operators will benefit as fewer tickets will have to be screened and locator resources are less likely to be deployed to locations where the operators don't actually have existing facilities in the ground. This will allow limited resources, including locators, to be focused more efficiently on other aspects of damage prevention, including improvements in locate accuracy. More accurate locates will reduce the risks of excavation damages and subsequently, reduce the risks to employees and the public. Obviously, as in the reduction in outgoing notification ticket numbers, if extrapolated more broadly across the state of Virginia and, indeed, nationwide, the benefits resulting from the significant reduction in the average notification area for locate requests would multiply exponentially.



	April	May	June	July	August	September	AVG
Control Area	1036839	844142	719308	672781	685642	652450	768527
Pilot Area	154338	146703	51199	17928	16027	101851	81341

Figure 3: Average polygon size for locate requests

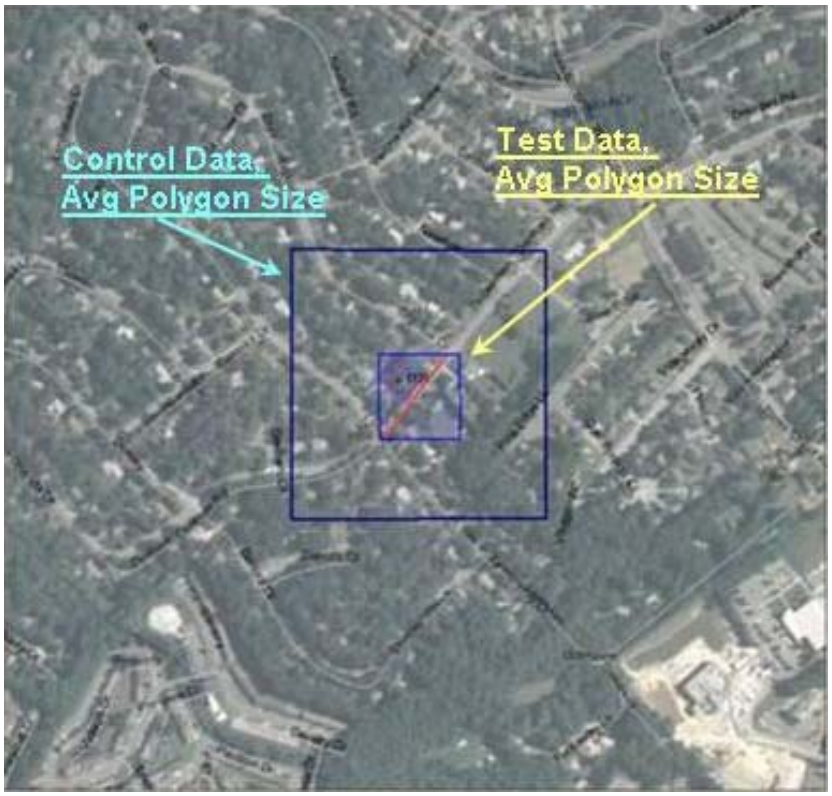


Figure 4: Comparison of Average Polygon Size

Several utility operators within Fairfax County have registered the entire county, including all cities within the county, for notification of locate requests. Therefore, regardless of the size of an original locate request, these operators will still receive a notification. Thus even greater savings could be achieved through tighter, more precise facility registration by utility operators.

Several additional data points were analyzed to determine the efficiencies gained from the VA Pilot Project.

3-Hour Notices: The Virginia Damage Prevention Act allows for a "3-Hour Notice" in the event that an excavator identifies clear evidence of an unmarked facility. The control data contained 4,274 "3-Hour Notices", representing 4.85% of the total 88,187 locate requests. The test data contained 42 "3-Hour Notices", representing 2.10% of the total 2,005 locate requests. Thus, the Pilot Project achieved a relative 56.78% reduction in 3-hour notices. If this reduction rate is applied to the control area tickets, it reduces the 3-hour tickets from 4,274 to 2,427. The remaining 1,847 3-hour tickets may have been avoided if pilot project technologies were used for the control area ticket users. Assuming excavators who called in these 3-hour tickets experienced downtimes ranging from one to three hours, the reduction in 3-hour tickets would translate to cost savings of approximately $320,000[9] to $1,000,000 for the control area ticket users. Applying the same logic to the state's entire number of 3-hour tickets, the cost savings to Virginia excavators could be between $2.9 million and $8.7 million.

Cancelled Locate Requests: In the control data 554 cancelled locate requests were processed, representing 0.63% of the total 88,187 locate requests. In the test data 8 cancelled locate requests were processed, representing 0.40% of the total 2,005 locate requests. Thus, the Pilot Project achieved a relative 36.51% reduction in cancelled locate requests.

Positive Response Codes: VUPS utilizes a Positive Response System that incorporates codes as a response from facilities locators. The following positive responses for test versus control tickets were compared as a metric for efficiency.

- *Code 60* is utilized when the locator and excavator agree to a marking schedule typically extending the marking period beyond the normal 48 hours. In the control data VUPS processed 23,184 Code 60 responses, representing 26.29% of the total 88,187 locate requests. In the test data, 178 Code 60 responses were processed, representing 8.88% of the total 2,005 locate requests. Thus, the Pilot Project achieved a relative 66.22% reduction in Code 60 responses.
- *Code 91* is utilized when the locator responds that there is an incorrect address. In the control data VUPS processed 4,439 Code 91 responses, representing 5.03% of the total 88,187 locate requests. In the test data, 68 Code 91 responses were processed, representing 3.39% of the total

[9] The cost savings are based on hourly down time costs noted on page 29 of the Business Case report for the Pilot Project issued in July 2006.

2,005 locate requests. Thus, the Pilot Project achieved a relative 32.60% reduction in Code 91 responses.

- *Code 93* is utilized when the locator responds that the scope of work is too large. In the control data VUPS processed 36 Code 93 responses, representing 0.04% of the total 88,187 locate requests. In the test data, there were no Code 93 responses processed. Thus, the Pilot Project achieved a relative 100% reduction in Code 93 responses.
- *Code 94* is utilized when the locator responds that the marking instructions are unclear. In the control data VUPS processed 535 Code 94 responses, representing 0.61% of the total 88,187 locate requests. In the test data, only 1 Code 94 response was processed, representing 0.05% of the total 2,005 locate requests. Thus, the Pilot Project achieved a relative 91.80% reduction in Code 94 responses.

Although the Pilot Project was not expected to have a direct effect on the metrics discussed above, it does appear that there is a direct correlation in the data suggesting the Pilot Project provided a more efficient locate request process. The Pilot Project locate requests were processed in a more timely and accurate manner.

Type	Control Area	Percentage of Area Total	Test Area	Percentage of Area Total	Relative Reduction
Total Requests	88,187		2,005		
3Hour Notices	4,274	4.85%	42	2.10%	56.78%
Cancellations	554	0.63%	8	0.40%	36.51%
Code 60	23,184	26.29%	178	8.88%	66.22%
Code 91	4,439	5.03%	68	3.39%	32.60%
Code 93	36	0.04%	0	0.00%	100%
Code 94	535	0.61%	1	0.05%	91.80%

Table 2: Pilot Project Metrics, Positive Response Codes

The bottom line is that the application of GPS technology to the one-call damage prevention process has been demonstrated through the Virginia Pilot Project to work to the benefit of all stakeholders.

Other Benefits

In addition to the efficiencies gained in the locate request process, as discussed above, some additional stakeholders took the opportunity to apply GPS technology outside of the test area. Several interstate pipeline operators utilized the availability of the enhanced VUPS mapping and existing GPS pipeline location information to assist them in creating more accurate locate requests.

One example of this was clearly demonstrated in a repair excavation performed by Colonial Pipeline Company ("Colonial"). During a routine smart pig[10] inspection, Colonial identified an anomaly in the wall thickness of one of its pipelines in Virginia. The smart pig being utilized captured and recorded the GPS coordinates of the location of this anomaly. Colonial entered a locate request using these coordinates to accurately identify the location for excavation and provided these same coordinates to its excavation crews. When the crews responded to the site to repair the pipeline, they used handheld GPS receivers to pinpoint the location of the anomaly. By containing the excavation to only that specific area, they increased both the efficiency of the locate request process and their own response time to repair the pipeline.

Another example of benefits resulting from the use of GPS technology is illustrated by a locate request ticket gridding issue discovered on a Columbia Gas Transmission pipeline construction project. The new pipeline segment extended over 17 miles through rural areas in northwestern Virginia. The locate requests submitted by the construction crews covered an area much larger than needed and in many cases were disjointed as illustrated in Figure 5.

[10] A "smart pig" is a device used to perform inline pipeline inspection. The tool is inserted into and moved through the pipeline. As the tool travels through the pipeline it uses non-destructive testing techniques and technology to identify and record potential pipe defects or abnormalities.

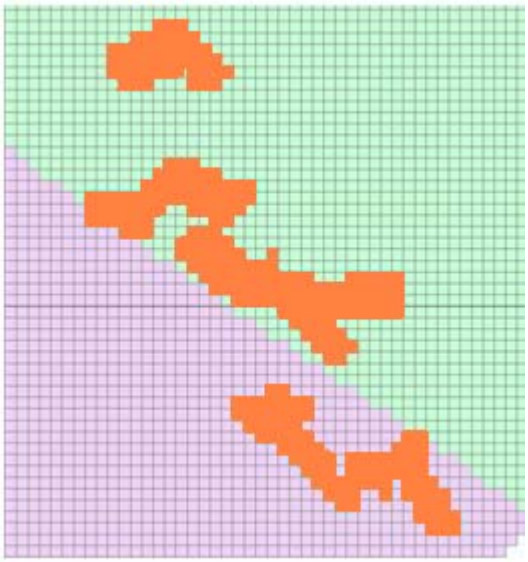


Figure 5: Grids initially selected for notification depicted in darker contrast

Following conversations with Pilot Project team members, the construction crews utilized GPS coordinates provided by Columbia Gas Transmission's pre-construction survey records to submit more precise locate requests. The notification areas were dramatically reduced as illustrated below in Figure 6.

Figure 6: Ticket gridded without GPS vs Notification area (polygon) using GPS

Excavator Feedback

Over the course of Phase I of the Project 25 users from 11 companies submitted locate requests using the Project technology (equipment and processes). The number of tickets submitted by individual users ranged from a high of 987 down to a single ticket. Similarly, the number of tickets submitted by individual companies over the course of the project ranged from over 1,600 down to 4. Factors affecting the large variations in the number of tickets submitted include the type of work performed by the excavator and the volume of work performed by the excavator in the test area of Fairfax County, VA.

During the Pilot Project, two meetings were held with participating excavators to get their feedback on the enhanced one-call process and the equipment being used. The first meeting was held just one month after data gathering began and served to identify and provide an opportunity to accommodate any needed corrections. The second meeting was held in the last week of the data gathering phase and served to gather input and feedback on the excavators' overall experience with the Project. Subsequent to the second meeting, all of the participating excavators were notified of an online survey where they could respond to the same questions and discussion items and were encouraged to respond to the survey if they did not participate in the meeting. The survey questions are shown in Appendix D.

In addition to the two meetings and the online survey tool as a means to gather excavator feedback, online and telephone user support was maintained and administered for excavators that encountered issues or problems for which they needed help. Also, members of the Project Team communicated with the excavators frequently over the course of the Project to encourage use of the technology and to help resolve any problems that might have been identified.

Key Messages From Excavators

Key messages received from the excavators are noted below.

- Participation in the Pilot Project has been beneficial

All excavator representatives attending the meetings or responding to the online survey reported personally using the Pilot Project technology (equipment and/or processes) to some extent. All excavator attendees generally agreed that participation in the Pilot Project has shown benefits to their own work processes. No excavators reported any negative impacts on their business processes or organizations resulting from their participation in the Project.

All of the excavators responded enthusiastically that the Pilot Project technology has been beneficial overall and that they planned to continue its use

beyond the Pilot phase. Several said that they want to see its application expanded into other counties in Virginia where they have more work.

All of the excavators indicated they were interested in Phase II (Electronic Manifest) and would be willing to participate as needed.

- Additional time in the field translates to improved efficiencies and quality

Some excavators reported that in some cases implementing the Pilot technology in the field required more time and attention to detail than is normally required by the excavator field personnel. Others reported that no significant additional time was needed for doing field entry of tickets. One reported that the shift to having the ticket information entered by the field excavator rather than an administrative person who has never been to the job site has helped to streamline the excavator's work process. On the other hand, another commented that the process created an additional step with smaller projects because the tickets were normally called in without making site visits whereas gathering GPS coordinates required site visits.

Additional time onsite to create a more accurate ticket is not seen as a negative if it can enhance the overall process. Most of the excavators agreed that any additional time required by field personnel is offset by the benefits in efficiencies and accuracies gained from the process. These include:

- Time saved in office hours, and
- Improved quality of the resulting tickets.

One excavator noted that the company pays people to go out to each job site and gather the correct ticket information. Their administrative staff then normally spends up to 3 hours per day entering ticket requests. They reported that it is more efficient when the field personnel can also enter the ticket information during their visit. Additionally, this shift in how the tickets were generated, including the use of the Pilot technology, reduces the likelihood that information would be lost or communicated incorrectly in the exchange of information from the field excavator to the administrative office person.

Most noted that the resulting tickets were more accurate with better details than were normally generated. Field personnel are able to add details about the excavation location which would not be possible if administrative staff were entering the tickets. More accurate ticket information results in fewer return visits needed to get more detailed or missing information.

Several excavators commented that walking the proposed excavation area to obtain GPS coordinates has helped with getting the area correctly mapped on the ticket. They noted that this creates less down time when going to a job site because the sites are marked correctly the first time, and that this creates a better sense of comfort knowing the correct area is marked.

Several of the excavators reported additional resulting benefits, including:

- noticeably smaller ticket areas than when administrative personnel called in the tickets;
- more return (positive response) codes showing the facilities have been marked than showing other codes;
- fewer 3-hour notices and re-marks;
- tickets seemed to be cleared sooner; and
- fewer return calls from the locator asking for more specific information in order to mark the site.

- Device form factor and functionality are important considerations

The type of equipment, its size and functionality, its durability and ruggedness, and its battery life are important considerations. Ease-of-use, perhaps facilitated through one-key operation and the use of a full-size keyboard, was also cited as a key factor for consideration. Thus, the Pocket PC or small PC form factor is seen as more functional and desirable for use than the cell phone. Another key equipment feature desired is the ability to save ticket information on the hand-held device when ticket data is entered to alleviate the need to retype the same information again.

- Use of a dedicated device is acceptable

Originally, the Project Team had selected the wireless equipment to be used in the Project (Motorola i605 cell phones and PPC-6700 Pocket PCs) with the specific consideration that the devices function in a multi-purpose role (e.g., receive GPS signals, communicate tickets to VUPS, and provide normal cell phone functions for other uses) so as not to add additional devices that field staff would have to manage. However, it was somewhat surprising that during the end-of-project meeting that the excavators almost unanimously agreed that a dedicated device would be acceptable and, perhaps, preferred if it exhibited all of the functionality and ease of use that was needed.

- Make the equipment and processes as simple as possible for ease of use

All of the excavators agreed that using the applications and equipment became easier with experience. It was suggested that the "key important factor" would be making the equipment as simple as possible for ease of use. Thus, the general consensus was that dedicated handheld units would be an acceptable possibility. As noted above, this refers to dedicated hand held equipment designed specifically to support the generation of locate requests from the field.

There were some specific additional comments and suggestions that were considered to be improvements in going forward and for future development.

- By far, the largest numbers of tickets submitted in the Pilot Project were from users of the i605 cell phones. However, all of the excavators agreed that an important and desirable consideration is that use of the Pocket PC

devices provides a full keyboard versus the repetitive keying needed on the cell phone application. Most agreed that a small handheld PC would also work well because of this consideration. A key pad or full-size keyboard with larger keys would help people who have larger fingers (i.e., most field personnel). Another possible option mentioned was the use of a stylus or pen (e.g., tablet PC).

- The Pocket PC units are useful in that the user is able to see a live version of the mapping immediately, whereas use of the i605 cell phone did not provide this function.
- There was some concern about the cost and the necessity of field personnel needing to keep up with another piece of equipment (separate from a cell phone). However, this was generally outweighed by the benefits.
- Cost is less a factor than functionality, as not all company employees need the equipment. The proposed use of a Blackberry-type device piqued the most interest.
- Cost isn't as important as ease of use. Developing a device with special keys, pre-programmed buttons and single key functionality to call up the application was suggested.
- A dedicated device would help. The cost/type of device and service would be a consideration especially for smaller excavators.
    - When asked if they would be willing to purchase a dedicated device, excavators responded that they would need to know the cost of the devices and the cost per month for the service. However, most noted that they would be willing to purchase the needed devices and services. They noted that submitting tickets through the Pilot process has resulted in fewer questions from the locators, especially on issues like cross streets.
- The required skill set and necessary training must be considered when introducing new technology. Most excavator field personnel have never entered locate request tickets (e.g., via web ticket entry) and training for this would be necessary.
- Need to make units more durable (rugged), even waterproof.
- One option might be to enable the use of voice commands combined via Bluetooth technology with the use of an ear piece. This would reduce the frequency by which the handhelds would need to be handled
- Need to be able to save the information on the hand-held device to alleviate retyping the same information again. Additionally, not having this capability sometimes creates double work as some excavators do one site visit to clear the site or to simply survey the site and then have to do a second visit to create the locate request ticket. Being able to create and save a ticket would alleviate this problem. Previously, web ticket entry was used and after the first visit the ticket could be entered from the office.
- Having just one additional piece of equipment versus two (e.g., smart phone & separate GPS receiver) is a useful consideration.

- Suggest using/developing a piece of equipment that would allow the user to access and use the full system (i.e., a device with adequate 'horsepower'). This might be a device developed and/or dedicated to the function and not necessarily adapted (as a cell phone is).
- Developing equipment options will offer a better opportunity to get more people involved. This should include several different types of equipment and a range of costs.
- A large capacity device could support the excavator in downloading and using electronic locator manifest data if it becomes available. The screen should be large enough to make it easier to view the manifest data.

- Technology produces accurate mapping of GPS coordinates

The excavators responded that the GPS coordinates were accurately mapped.

- Use of technology did not result in lost tickets

There were no lost tickets resulting from implementation of the Pilot technology.

- User support/help desk is necessary

The excavators noted that overall the Project Help Desk was always responsive to help resolve any issues. This discussion confirmed that it is critical that a live help desk be available to resolve issues that arise during implementation of new and existing technology and processes.

- Processes could be integrated into excavator work management systems

Typically for utility work, a site visit is performed by an engineering / design group. If the electronic white-line were to be captured at this point and stored within a work management system, the data could later be downloaded to the contractors work management application. The excavators were asked if it would be practical to integrate use of the Pilot technology into their normal work processes and work management systems. One excavator responded that it would be practical if they could set up to use their own work management system in the handheld equipment. Another said it would be more practical if the option was provided to start from their work management system and move into the ticket screen and submit the tickets.

Suggestions for enhancement and improvements

Some of the excavators offered suggestions for enhancements and improvements to the Pilot technology. These included:

- Expand implementation of the technology to other areas of Virginia where some of the participating excavators do more work.

- Provide the ability to input and submit other types of locate request tickets using the Pilot technology. This would include 3-hour tickets, requests for re-marks and update tickets. Those tickets still had to be placed via telephone to VUPS during the Pilot Project.
- Provide the ability for the excavator to view the positive response on the handheld equipment. In fact, all data related to a ticket should be accessible in that manner.
- Provide the ability to print out the ortho-photographic map of the area where the GPS points were captured.
- Provide the excavator the ortho-photographic maps with the facility locate lines overlaid (i.e., Phase II). These could then be printed for use by the field crews.

Conclusions & Recommendations

This project has demonstrated that the application of GPS technology in electronic white-lining can be of significant benefit to the one call process. The 8.04% reduction achieved in the ratio of outgoing notification tickets to incoming locate requests is considered significant and is projected to result in significant savings in locate costs if applied throughout Virginia. If applied across the nation it could result in savings of hundreds of millions of dollars.

Perhaps more significant is the reduction in average polygon size. This has tangible benefits to all stakeholders and can result in significant cost reductions and improvements in safety. Likewise, the improvements demonstrated in process efficiencies will result in cost savings, improved locate accuracy, and improved safety.

The data suggests the Pilot Project provided a more efficient locate request process, ensuring that locate requests were processed in a more timely and accurate manner. This is considered to have come from improvements in the quality of information on locate tickets achieved through application of the process.

- The quality of ticket information is improved on the tickets submitted by the excavators in the field.
- The reduction in notification area achieved during the Project means that operators will be more likely to receive valid locate notification tickets where they actually have underground utilities in the area of the excavation.
- A significant reduction in 3-hour locate requests means that locators can better plan their work and work more effectively.
- Using improved information and having to address smaller areas means that locator response and completion times are reduced, making their work more efficient, allowing more time to locate facilities more accurately and enabling their work to be carried out more safely.

It is recommended that the CGA consider this application of technology as a Damage Prevention Best Practice. It is also recommended that other one-call centers consider the development and use of this technology. In support of this recommendation, the directors of VUPS and Arizona Blue Stake have offered to be available for consultation and assistance.

The level of accuracy when implementing the Pilot Process will be directly dependent on the level of accuracy of the one-call center's base maps. And, although not required, ortho-photographic maps are an excellent enhancement.

There are certain basic requirements that must be met to enable implementation of this technology for other one-call processes.

- Develop the software for the use of the technology through the individual one-call center application provider.
- Develop and adopt the use of polygons for locate request ticket entry and utility facility notification area registration. (See Figure 7, below.)

- Create and implement a centralized help desk to rapidly respond to any process issues.
- Develop training programs and provide adequate personnel to train stakeholders.

Following are suggestions for successful implementation:

- Create active stakeholder groups to encourage participation.
- Encourage utilities when developing contracts to require use of technology.
- Encourage utilities to minimize facility notification area registrations/buffer zones in line with their safety and protection requirements.
- Develop metrics to measure performance and potential gain in efficiencies.

Figure 7: Polygon notification area versus grids

Promoting further implementation of the technology

A bilateral approach will be utilized to promote the benefits of electronic white-lining demonstrated in the VA Pilot Program. This will include promoting the benefits to all stakeholders through a nationwide pubic awareness campaign while concurrently promoting and marketing further implementation of the established process within Virginia.

Nationwide

The nationwide initiative will be directed at presenting information about and results of the VA Pilot Project at major stakeholder and industry association meetings. These include several past and future scheduled meetings:

- North American Telecommunications Damage Prevention Council (NTDPC) – October 2007
- One Call Systems International (OCSI) – November 2007
- Damage Prevention Conference – December 2007
- Common Ground Alliance (CGA) – March 2008

Efforts will also be made to present to future meetings of the following industry associations:

- American Public Works Association (APWA)
- National Utility Contract Locators Association (NULCA)
- National Utility Contractor Association (NUCA)
- Association of General Contractors (AGC)
- American Gas Association (AGA)
- American Public Gas Association (APGA)
- Edison Electric Institute (EEI)
- International Pipeline Conference (IPC)

The results from the VA Pilot Project will be submitted to the CGA for consideration in the development of damage prevention best practices. The CGA Best Practices are used throughout the industry as guidelines for damage prevention performance.

The technology and processes demonstrated in the VA Pilot Project will also be promoted among the various one-call software providers. Currently any Norfield Data Products users will require only slight modification to the one-call software that has already been developed and is in use. IRTH Solutions has begun to develop compatibility with the VA Pilot Program process. Between these two one-call software vendors, enhanced electronic white lining as demonstrated in the VA Pilot Project could be readily developed in the following states:

- Arizona
- California
- Colorado
- Florida
- Kentucky
- Indiana
- Michigan
- Nebraska
- Nevada
- North Carolina
- New York
- Ohio
- Utah

Other technology providers may also choose to make offerings in support of similar efforts across the country. As noted previously in this report, prospective vendors proposed a range of solutions based on several different technologies, several of which could have been incorporated to address the goals of the VA Pilot Project. The primary differences in the technologies were the purported accuracies of the GPS coordinates that could be obtained and the processes used to communicate those coordinates to the One-call Center.

Precise (sub-meter) GPS accuracy could be used but was determined not to be necessary for achieving adequate results and benefits in this application. In fact, the significant added cost and user constraints exhibited by higher accuracy devices would tend to inhibit their acceptance by excavators. Cost and ease of use are considered to be significant determinants to widespread adoption of enhanced technology by excavators.

GPS accuracy in the 3-10 meter range proved to be acceptable and supportive of the goals of the VA Pilot Project. Field testing often resulted in device accuracies greater than those purported by the vendors. Also, one-call centers and facility operators often add buffers for conservatism to any locate request.

Virginia

Additional efforts in Virginia will focus on promoting the technology and benefits demonstrated in the Pilot Project in order to maximize further usage throughout the state. Utilities and their excavation contractors are the largest users of the one-call system in Virginia and initial efforts will focus on this stakeholder segment. This process has already begun by various stakeholders in eastern Virginia through the modification of the application to support other mobile device platforms, such as Research in Motion's (RIM) Blackberry platform. These modifications will minimize the restriction that the tested technologies be device specific, and encourage participation of a larger stakeholder audience.

The vendors supporting the Pilot Project have already begun developing pricing structures for the various associated services. Those vendors have also begun development of marketing brochures to identify and summarize the benefits

of utilizing the process. Other communications services vendors can also develop services based on the Pilot Project results and in coordination with VUPS.

The Virginia effort will reach out to various damage prevention stakeholder industry associations within the state, including:

- Richmond Area Municipal Contractors (RAMCA)
- Hampton Roads Utility Contractors' Association (HRUCA)
- Heavy Construction Contractors' Association (HCCA)
- Virginia Municipal League (VML)
- Virginia Gas Operators Association (VGOA)
- Virginia Cable Telecommunications Association (VCTA)
- Virginia Telecommunications Association (VTA)

The membership of VUPS will also be reached through broadcast messages delivered through the VUPS' ticket notifications system and presentations at the VUPS' quarterly membership meetings.

Future Application of Technology

Phases II and III are not within the scope of this report, but have been discussed by the participating stakeholders as further developments that could increase impact to multiple stakeholders in the one-call process.

Phase II will involve the application of GPS technology to locating instruments and the development of electronic manifests of the locator's activity. It is envisioned that the utility markings would be overlaid onto the ortho-photographic maps to provide a bird's eye view of the excavation site. This will also improve the detail currently seen in some manifest records. See Figures 8 and 9 below for illustrations on current and projected locator manifests.

Utility operators could use the data from Phase II as a verification of their own maps and records. Excavators have indicated they would benefit from having access to the electronic locate records.

Phase III will involve the integration of GPS and mapping technology on excavating equipment.

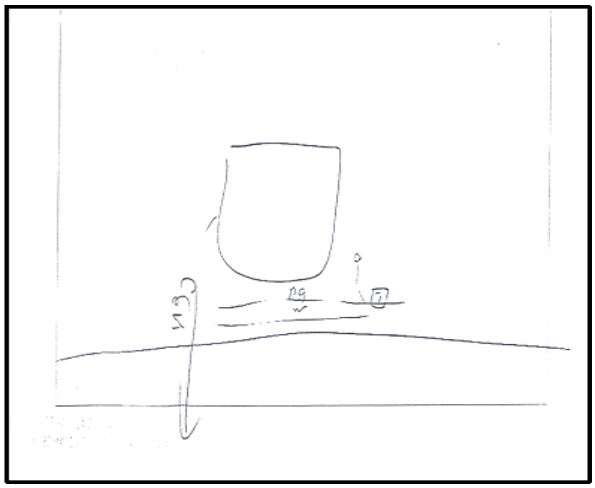


Figure 8: An example of a hand-drawn locator manifest

Figure 9: Projected electronic manifest overlaid on ortho-photograph

Appendix A: Focus on Over-notification

One Call Systems International (OCSI) is an affiliated committee of the Common Ground Alliance. OCSI 2006 statistical data from 25 state one-call centers[11] showed a total of 19,284,720 incoming locate requests to one-call centers. This resulted in 120,107,711 locate notification tickets. Conservatively, it can be assumed that the annual total number of incoming locate requests to one-call centers in the United States could easily be as high as 25 million per year when including all 50 States. Assuming a conservative rate of 6 outgoing locate notification tickets generated for each incoming locate request, the total number of locate notification tickets issued to underground facility owners/operators could exceed 150 million per year.

Underground facility operators commit significant time and resources in reviewing locate notification tickets and in performing facility locating and marking activities. They must respond to each locate notification ticket received from the one-call center. If the initial review of a ticket determines the operator's facilities could be affected by a planned excavation, then generally a field locating crew physically locates and marks the location of the facilities prior to the excavation.

Excavators risk downtime and additional expenses if facility locates are not performed in a timely manner or if they are not performed accurately. Additional risks can result, including possible injuries and fatalities of employees and the public, if facilities are damaged during excavation.

Locate requests that identify areas much larger than the actual planned excavation areas have a significant impact on the one-call process. These may result from an excavator who broadens the locate request area to ensure it encompasses the actual area of the excavation. Larger than necessary notification areas may also result from underground utility operators that place additional buffers for notification around their facilities because of their lack of confidence in the accuracy of the present system. This perceived lack of accuracy may result, in part, from the resolution of the one-call center base map or the mapping technology used that may not be adequate to effectively discriminate the appropriate area specifically affected by the locate request. Since facility operators must respond to each locate notification ticket, these cases result in what is known as "over-notification". Over-notification draws upon operator and locator resources in an inefficient and ineffective manner. Depending upon the nature of the operator's facilities, over-notification can affect from 40% to 60% of the total locate tickets issued.

[11] Alabama, Arizona, California, Colorado, Delaware, Florida, Georgia, Hawaii, Indiana, Kentucky, Maryland, Michigan, Montana, Nevada, New York, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas (1 of 3), Utah, Virginia, Washington (1 of 3), Wisconsin and Wyoming

Locate requests that are too vague or that are incorrect in their description of the excavation location pose another major impact to the one-call process. These occurrences can result in the operator/locator being unable to determine where the actual excavation is to occur or locating and marking facilities in the wrong location.

Over-notification and incorrect excavation location information unnecessarily detract owner/operator and locator resources. Improved accuracy in communicating the exact location of planned excavations when requesting facility locates can serve to reduce the overall costs of damage prevention and re-focus efforts on the efficient performance of effective and accurate locates. This could result in further reductions in the number of facility damage incidents.

Current technologies can be refined or new ones developed to:

- Significantly improve the efficiency and accuracy of excavation and facility location information communicated between excavators and owners/operators of underground facilities;
- Reduce the cost of damage prevention programs to all stakeholders; and
- Improve the reliability and safety of the nation's underground facility infrastructure.

Appendix B: Enhanced One-call Process Used in Pilot Project

Enhanced One-call Process

Following is, in general, the enhanced one-call process implemented in the Virginia Pilot Project for One-call Location Technology.

- The excavator determined the GPS coordinates (latitude and longitude) of the planned excavation site using GPS and telecommunications hardware and software selected and/or developed for the Pilot Project. Alternatively, in some cases, the excavator or site developer may have determined the GPS coordinates of the proposed excavation site from construction drawings or a work management system. These latter GPS coordinates would have been determined at some previous time by high-accuracy GPS technology or land-survey methods.
- The excavator or site developer created an electronic locate request utilizing software developed for the Pilot Project and electronically transmitted it to the VUPS one-call center.
- The VUPS one-call center received and processed the locate request, utilizing the GPS coordinates of the planned excavation site and adding any necessary buffers to produce a polygon representation of the excavation site on the GPS-aligned base map.
- Once the VUPS one-call center issued a locate request number to the excavator/requestor, the one-call center issued locate notification tickets to the owners/operators having facilities within the planned excavation area. The locate ticket included the notification ticket number, mapped GPS coordinates, and other required data.
- Upon receipt of locate notification tickets, facility owners/operators reviewed the tickets to determine if the planned excavation had the potential to damage their facilities. They determined that the tickets were either “Clear, No Conflict” and notified the one-call center, or they dispatched field locate crews to locate and mark the affected facilities.
- If dispatched, locators proceeded to the planned excavation area, utilizing a handheld GPS device to match the GPS coordinates, a text description of the excavation area, or other means to confirm they were in the correct location. The locators did not try to match the exact, point-to-point, mapped GPS coordinates determined by the excavator. It was considered adequate that the locators confirmed they were in the correct geographic area and located and marked the facilities in the area of the intended excavation.

- The locators completed the field locates and marked the affected facilities. The locators notified VUPS, utilizing the current positive response process via mobile computer technology, providing the appropriate positive response codes.
- Excavators could review the status of their locate requests over the Internet, were required to follow the requirements of the law and should have implemented applicable damage prevention best practices.

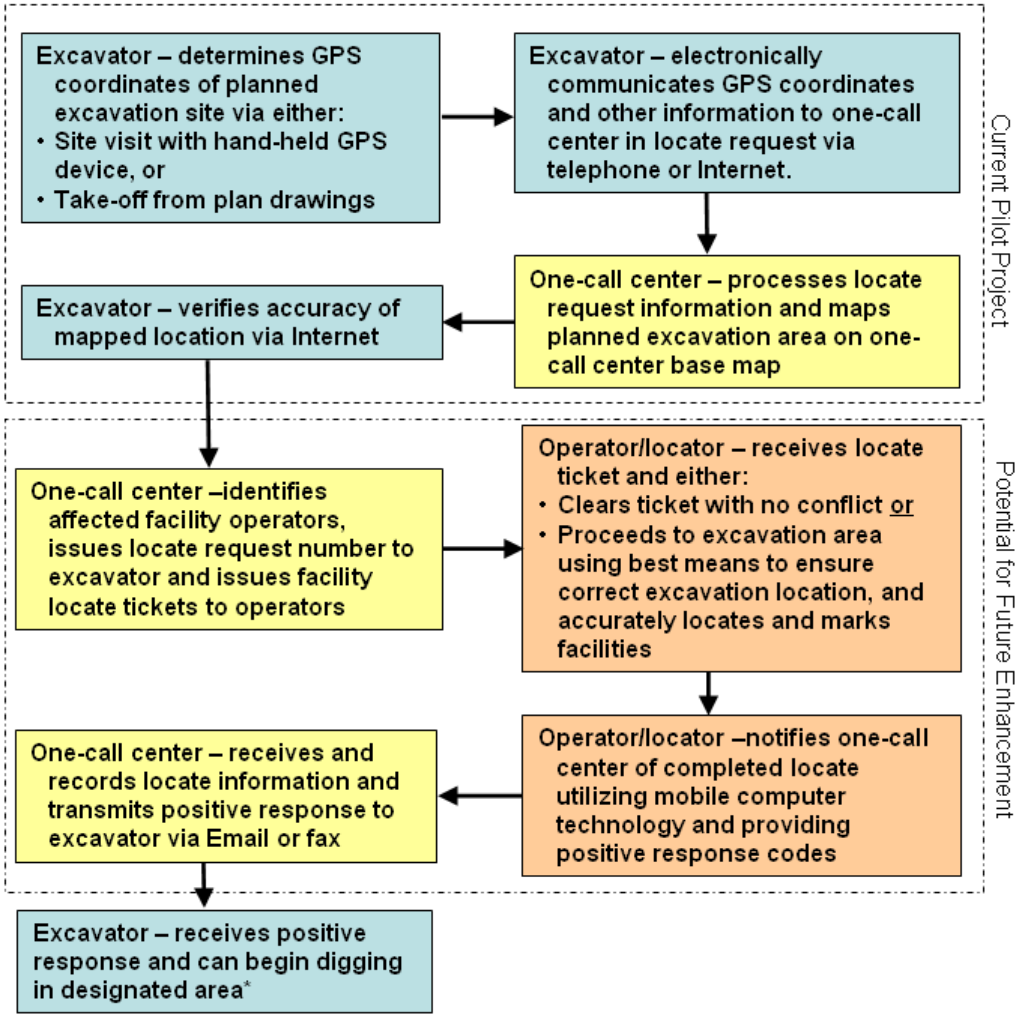


Figure 1: One-call Process Flow Chart

Technology Application

Two technology approaches were utilized in conducting the Pilot Project. The first approach was the use of a GPS-enabled cellular phone to transmit an XML formatted data file to a VUPS suspend server. The second approach was the use of a handheld GPS receiver coupled via Bluetooth technology to a Windows Mobile v5.0 Pocket PC or Smart Phone. For both of these approaches, custom software applications were developed to facilitate the communication of the locate request information, including the GPS coordinates, to the VUPS ticket entry system through a web-based service.

GPS-enabled Cellular Phone:

If the excavator was using a GPS-enabled cell phone to transfer XML data to the VUPS suspend server:

- If the locate request was being performed while cellular service was available, the requestor entered a unique identifier (perhaps a work order number) and captured the GPS point(s). The requestor could enter additional information for the ticket request at that time. The XML data was sent to the one-call center and held in a suspend queue as incomplete or unverified. The requestor then logged into the queue using a desktop or laptop PC, retrieved the individual locate request records, verified the accuracy of the mapped location information or made any required adjustments, and entered any additional data needed to complete each request. The VUPS one-call application then generated the locate request numbers and issued them to the requestor.

- If the request was being performed while no cellular service was available, the requestor entered a unique identifier (perhaps a work order number) and captured the GPS point(s). The requestor could enter additional information for the ticket request at that time. This data was stored locally on the device until cellular service was available, whereupon the XML data was sent to the one-call center and held in a suspend queue as incomplete or unverified. The transmitted data could have been a single locate request or multiple requests that were sent to the queue. The requestor then logged into the queue using a desktop or laptop PC, retrieved the individual locate request records, verified the accuracy of the mapped location information or made any required adjustments, and entered any additional data needed to complete each request. The VUPS one-call application then generated the locate request numbers and issued them to the requestor.

Pocket PC Smart Phone

If the excavator was using a handheld GPS device combined with a Pocket PC/Smart Phone using the Microsoft Mobile platform:

- If the locate request was being performed while Internet access was available, the software application developed for the Pilot Project performed real-time data transmission to a customized VUPS web ticket entry system. The VUPS one-call ticket software application displayed the mapped, requested coordinates, and the requestor either acknowledged that the map was correct or made adjustments as required. Once the locate request was verified, VUPS determined which owners/operators had facilities within the planned excavation area. This information was added to the completed locate request and a request number was issued to the requestor.

- If the locate request was being performed while no Internet access was available, the software application stored the data on the Pocket PC/Smart Phone. The requestor entered a unique identifier (perhaps a work order number) and captured the GPS point(s). The requestor could have entered additional information for the ticket request at that time. This data was stored on the Pocket PC/Smart Phone until Internet access was available and the requestor could access the VUPS web ticket entry system.

Appendix C: Participating Companies

- Arizona Blue Stake
- Colonial Pipeline
- Common Ground Alliance
- Cycla Corporation
- D A Foster Company
- Danella Construction Company
- Dominion Virginia Power
- Fairfax County Water Authority
- Fiber Technology
- Gonzalez Brothers, LLC
- Lineal Industries
- Long Fence
- Norfield Data Products
- Northern Pipeline Construction Co
- Pipeline Research Council International
- Seabar Communications Inc
- Shirley Contracting Co LLC
- Sprint Nextel
- S W Rodgers Co Inc
- Trimble
- U. S. DOT, Pipeline and Hazardous Materials Safety Administration
- Utiliquest, LLC
- Verizon
- Vettro
- Village Landscapes And Irrigation Inc.
- Virginia State Corporation Commission
- Virginia Utilities Protection Service
- Washington Gas
- William A Hazel Inc

Appendix D: Questions for Excavators

1. Did you personally participate in the Pilot Project by using the equipment and processes?
2. If not, did you supervise someone else in your organization that used the equipment and processes?
3. Has your participation in the Pilot Project provided benefits to you and your organization? If so, can you briefly describe what those benefits are?
4. Has your participation in the Pilot Project had any negative impacts on your work or organization? If so, can you briefly describe what those impacts are?
5. Have the benefits or negative impacts of your participation in the Pilot Project improved as you became more familiar with the applications?
6. Is the equipment adequate for use in the field (usability, ruggedness, screen readability, etc.)?
7. Are the GPS coordinate readings taken in the field accurately rendered into line and polygon shapes and layered onto maps to depict the planned excavation areas?
8. Have you or has your organization encountered any problems with the equipment or applications that resulted in lost ticket requests that had to be resubmitted? If so, can you briefly describe what those problems were?
9. Were problems encountered where the locator was unable to find the planned excavation area or failed to locate and mark the area accurately?
10. Were any problems you encountered adequately and efficiently resolved?
11. Do you plan to continue to use the Pilot Project technology and processes to submit your one-call locate requests following completion of the Pilot Project?
12. Would it be practical to integrate the Pilot Project process into your normal work process? Is it practical? Does it fit? If not, what changes would be needed to encourage such integration?
13. What enhancements, improvements or modifications, if any, would you suggest to the current Pilot Project technology and processes as you understand them?
14. Please describe and discuss any benefits, problems or issues related to the Pilot Project that you would like, other than those noted above?
15. Phase II of the Pilot Project will focus on facility locators using GPS technology to develop electronic manifests. Do you have any suggestions or recommendations for consideration in Phase II?
16. Would you be willing to participate in Phase II if needed?

Appendix E: Stakeholder Benefits Table

Benefit from GPS-enhanced electronic white-lining	Benefiting Stakeholder				
	Public / Environ.	Excavator	One-call Center	Operator	Locator
Improved safety and reliability of underground utilities	*	*		*	
Improved efficiency and accuracy in communicating excavation and facility location information between excavators and facility operators		*	*	*	*
Reduced cost of damage prevention programs				*	
Improved accuracy of locate ticket information		*	*	*	*
Ability to see excavation area mapped on handheld device		*			
Fewer field visits to gather locate ticket information		*			
Fewer return calls from locator asking for more specific information		*			*
Reduced time from submission of a locate request to being cleared to work		*			
Reduced risk of downtime, enforcement actions and litigation resulting from damage incidents		*		*	*
Reduced time required to process locate requests		*	*		
Reduced ticket processing costs through automated ticket input/output			*		
Improved quality of service from one-call center		*	*	*	
Reduced over-notification				*	
Reduced numbers of incorrect tickets		*		*	*
Reduced footprint for locate areas for grids and polygons				*	*

Increased "clear, no conflict" ticket rates		*			
Increased "clear, no conflict" ticket rates without need for field locates				*	
Improved personnel safety by allocating more time to perform locates					*
Improved locate accuracy through more efficient use of resources and allocating more time to perform locates		*		*	*
Allow limited resources to be focused on other aspects of damage prevention				*	
Improved positive response efficiencies through:					
Reductions in 3-hour notices		*		*	*
Reductions in cancelled locate requests				*	*
Reductions in extended marking schedules		*			*
Reductions in incorrect address responses		*			*
Reductions in scope of work larger than allowed responses		*			*
Reductions in marking instructions unclear		*			*