Technology REPORT

Technology Advancements & Gaps in Underground Safety

CGA™
Common Ground Alliance

Published March, 2018

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Introduction

With the ever-changing technology landscape in the damage prevention industry, companies are forced to stay abreast of the evolving environment. The Common Ground Alliance (CGA) Technology Committee would like to contribute with the first annual Common Ground Alliance Technology Report. The report was developed as a resource to help the damage prevention industry identify and understand the importance of technology used to prevent damages, protect assets, and increase overall safety.

This report is meant to be a snapshot in time—a record of the technologies in use and under development for a specific year. The report's vision is to become a record of progress and source of inspiration for new applications of existing technologies and the development of new technologies. We include gaps in technology or “challenges to solve” that might supply a spark to help create new ideas and support for research and investment. We also hope to share the information we collect about the successful applications of technology, which may eventually lead to the adoption of new Best Practices and raise the overall level of industry knowledge.

Finally, we want to provide a place for those deploying new technology to share their successes through case studies. CGA does not promote or endorse any specific products, companies, or vendors. Our focus is on the technologies and their applications to damage prevention. For this reason, the case studies are the only place where specific vendor or product names are mentioned.

Parties interested in learning more about a specific topic or about making contributions to this report are encouraged to reach out to the CGA Technology Committee for more information. Please visit http://commongroundalliance.com/about-us/commitees/technology.

Technology Committee Mission

Drive the industry to develop and utilize innovative technology that will decrease the probability or consequences of excavation damage in support of CGA’s overall mission.

Technology Committee Vision

Identify opportunities to improve technology and damage prevention processes to decrease the likelihood or consequences of excavation damage.

Provide CGA members with information on current and emerging technologies that can help prevent excavation damage.

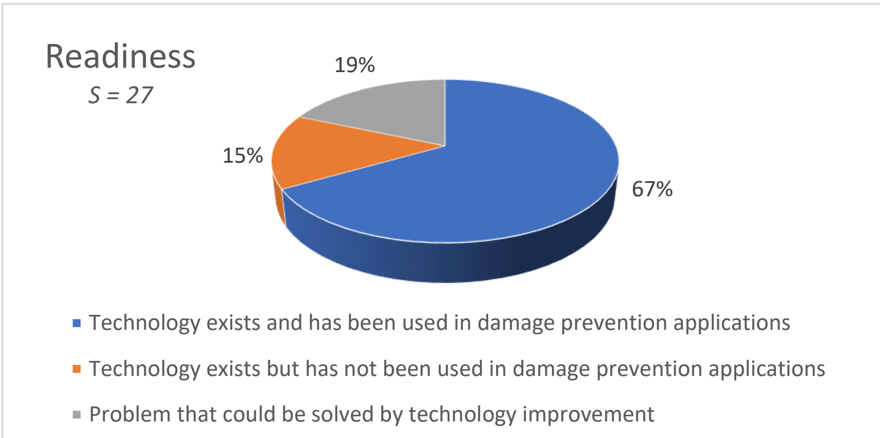
What Is in This Report?

- The 2017 results of our Technology Collection Form, an ongoing industry inquiry of technology
- A list of gaps or opportunities where technology can possibly be used to help prevent damages
- A list identifying technology currently being utilized
- An important selection of case studies: Article-length submissions from those working to use or deploy new technology

Technology Responses

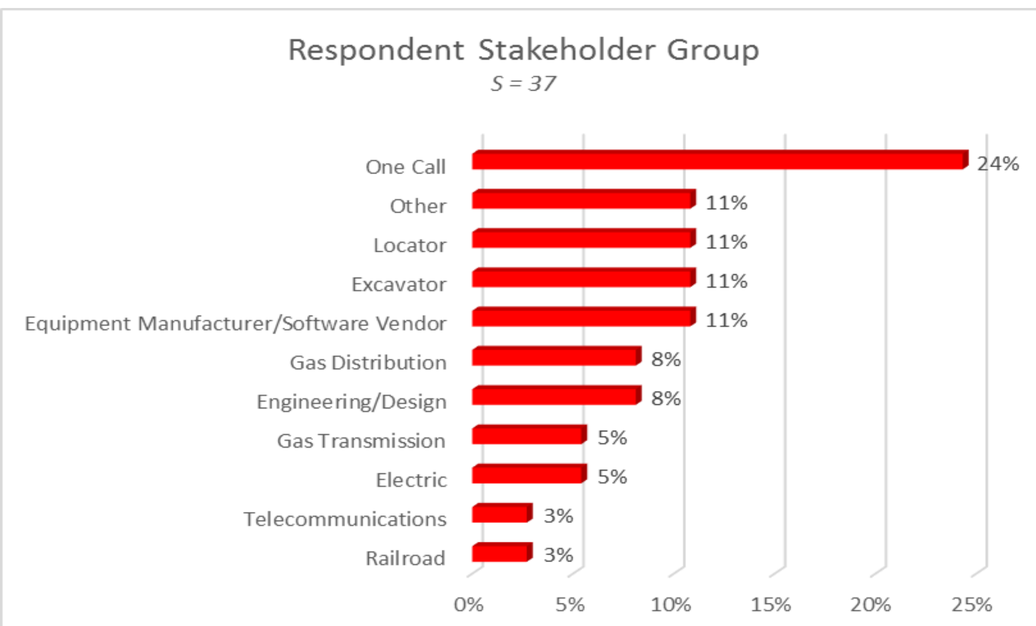
The following are questions and results from the Technology Collection Form hosted on the CGA Technology Committee website: http://commongroundalliance.com/programs/technology. The form remains continuously open for new responses. There were 27 responses as of Nov. 30, 2017. Some questions could be left blank, and some could have more than one selection, so totals vary. In the following charts, "*S*" indicates the sample size.

Are you reporting a technology that has already been put to use with provable results or identifying a problem that could be solved by a specific technology improvement?

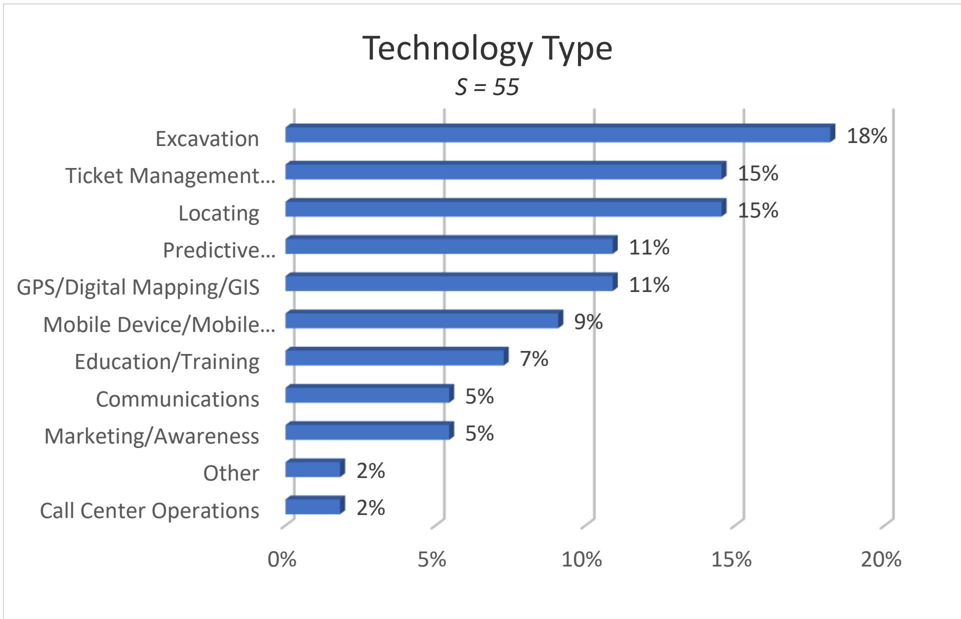


Please select your stakeholder group(s)

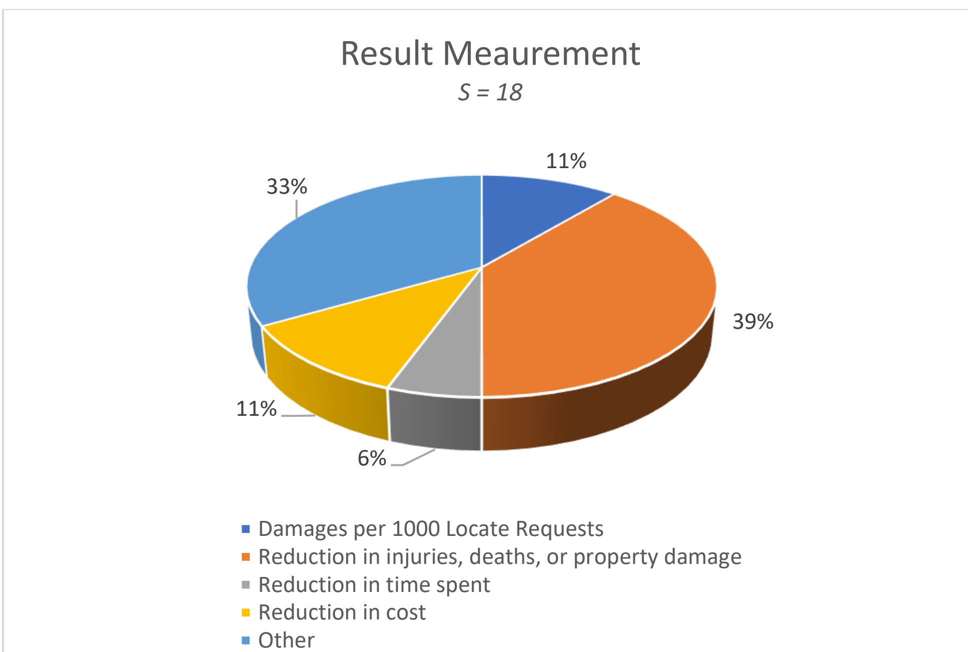
(Respondent could select more than one group, e.g., Equipment Manufacturer and Engineering/Design)



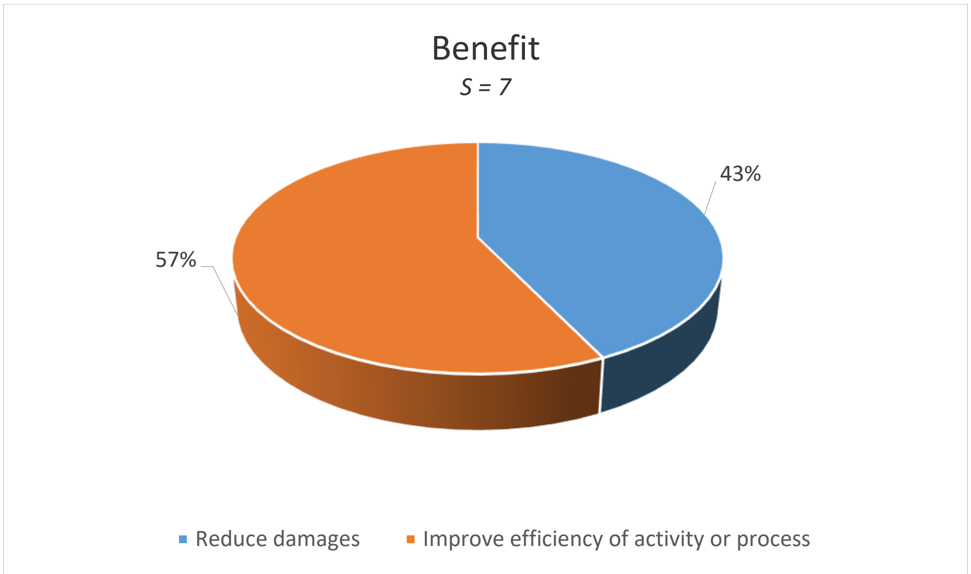
What type of technology improvement are you reporting, recommending, or suggesting? ***(A technology could fit more than one type.)***



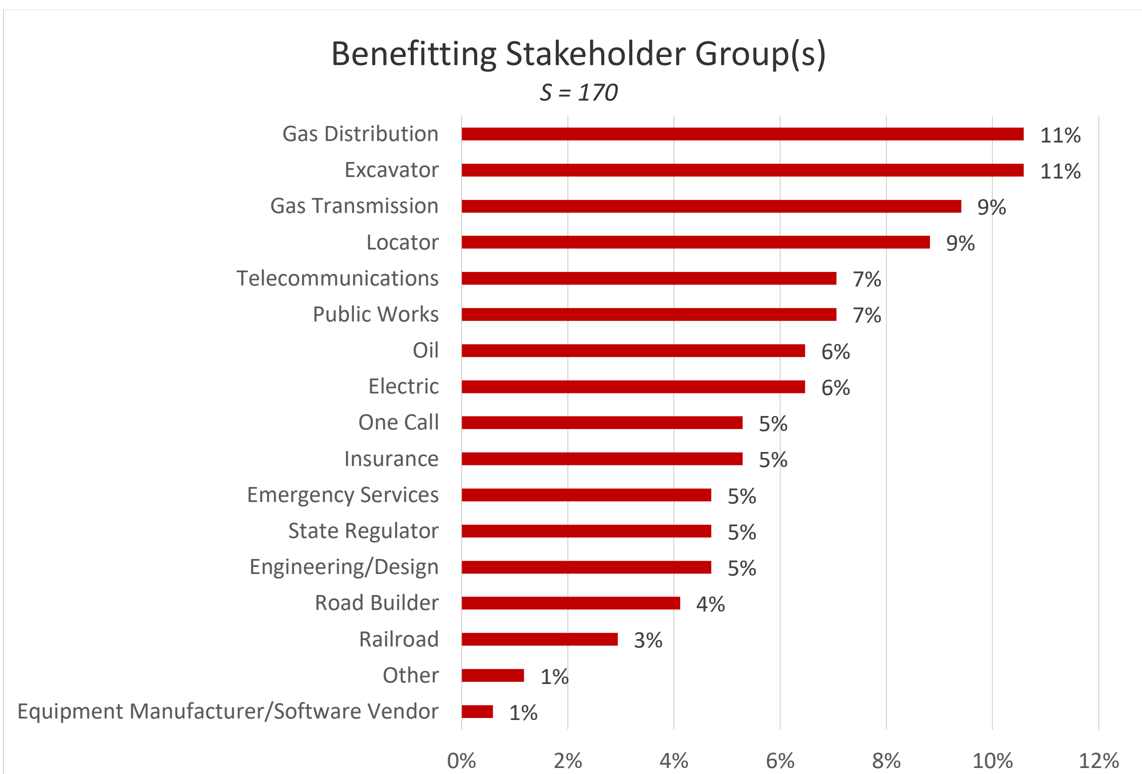
How were the results measured?



If the problem could be solved or the new technology could be used in our industry, would it reduce damages or improve efficiency of a damage prevention activity or process?



Which stakeholder group(s) have or could benefit from the technology improvement? *(A technology could benefit multiple stakeholder groups)*



2017 Submissions from the CGA Technology Collection Form

Although the collection form is technology-centric, it is not limited to just the identification of a new technology. A practice using technology may also be submitted that describes known technology and provides examples or suggestions to use it for damage prevention. This is an overview of the submissions we received.

Existing Technologies Submitted in 2017
Fiber optic encroachment detection—now used for railroads
Predictive analytics/risk assessment—provides an automated way to assess and reduce the number of locates and resources needed to help prevent damage
Ticket management and processing—Enhanced communications (in addition to the locate) to contractors about the presence of facilities
Ticket access software, including specific safety information, for faster responses
Nosey Neighbor postcard—ticket address is geocoded, and neighbors receive mailing with 811 information
Excavator—high-frequency induction sweep for extra measure of safety
Reduction in time spent locating by using automatic flag inserter
Mobile software app capturing locating data and field form data, photos, and sketches
Cloud and mobile asset lifecycle management married to enterprise systems

New Technologies Submitted in 2017
Ticket risk assessment—each ticket is assessed a risk score from 0–6. Highest risk tickets get field personnel visits with the excavator
Ticket management and processing—mobile access to photos of locating marks, see locator's photos before excavation, tie photos to ticket numbers
Documentation and damage prevention construction app—simple app that allows users to document their projects and use safe dig checklists and customizable forms
Documentation of job sites before excavation—forces a closer look by excavator and increases jobsite awareness
LSBUD (Line Search Before You Dig) uses ticket access software to allow asset owners rapid responses to third-party ticket requests improving response times, national portal to provide response for tickets in minutes
Buried excavation alert system
Mapping metallic and non-metallic lines with sensitive radio gradiometer that reads reradiated AM signals and mobile electrons, anions, and cations from anaerobic bacteria strains
Field inspection data collection software to support use of building information modeling (BIM) philosophy

New Gaps (Needs for Technology) Submitted and Technology that could be used to fill existing gaps
An affordable technology that could measure outreach (marketing/awareness) and tie to locate request and damage information
Specialized leak detection laser-based gas sensor—measures multiple gases to separate and ID artificial leak sources from natural emissions, can be used for rapid and autonomous systems
Virtual white lining
Predictive analytics/risk assessment—software claim system, root cause analysis for electric lines
Intrinsically locatable plastic pipe
Data visualization—damage prevention efficiency, data management
Technology or entity to address seasonality of locating requests
Standardization of GIS data
Promote and establish utilization and wider acceptance of hydro/vac excavation
Ensure 100% integrity of all tracer wires or do not allow non-traceable utility lines
Require utility owners to have accurate as-built plans, both new and existing

Technology Opportunities or Gaps in Underground Technology

This section lists gaps that the Technology Committee has identified from various meetings within CGA and the utility industry. It illustrates opportunities for technology development to fill these gaps and help increase technology use in damage prevention.

Locating

- Locating non-metallic lines
- Locating and tracking abandoned facilities
- Mitigating signal bleed over to non-target lines while using locating instruments
- Obtaining reliable depth measurements (Z) from locators; depth of cover over assets
- Creating better ways to ensure that new buried assets are locatable
- Standardizing localized tools using radio frequency identification (RFID) (or equivalent) markers
- Developing locator personnel qualification tools
- Developing locator audit tools

Excavation

- Improving excavator identification—providing excavation companies with unique IDs
- Detecting excavation encroachment on pipelines
- Detecting excavation activity close to facilities/assets
- Developing combined systems for encroachment detection (camera + fiber optic)
- Linking the movements of excavators to utility GIS systems—creating a warning when close
- Cost reduction and plug-and-play of encroachment detection

GIS = Geographic Information System

GPR = Ground Penetrating Radar

GPS = Global Positioning System

- Developing trenchless excavation
  - Soft excavation tools (vacuum and hydro excavating)
  - Less expensive test hole technology
  - Use of sensors on drill heads to detect potential conflicts
  - Use of post-bore pull-back cameras
- Using white lining technologies—electronic
- User-friendly GPR system to deploy for helping construction crews avoid utilities
- Using under-canopy GPS encroachment detection
- Using infrared radiation (IR) wavelengths to confirm equipment activity
- Integrating imagery for proximity threat detection
- Making excavators aware of utility location without using paint on the ground

GPS/Digital Mapping/GIS

- Accurate mapping of underground facilities
  - High-accuracy GPS collection and mapping of assets—less than 1 meter
  - Collection of Z data and depth of cover over assets
- Mapping near misses—collecting and enabling use of this data
- Mapping damage locations
- Enabling data sharing
- Identifying facilities currently not mapped, recorded or known
- Making the GPS mapping technology usable by construction crews
- Integrating GPS mapping and GIS in real time and workflow
- Using routine maintenance opportunities to GPS-record assets
- Creating “open” GIS systems/better sharing of the data
- Mapping assets through mainline inspections and associating location with video
- Providing better GPS signal strength in urban canyons and under tree cover
- Providing software analysis for quality feedback about GPS coordinate collection
- Developing standards for GPS data quality

Predictive Analytics/Risk Assessment

- Analyzing root causes of damages
- Using predictive modeling from the data that is already available
- Combining leading indicator tracking with patrolling and surveys; examples include
  - Plans for construction
  - Social activities
  - Traffic patterns
- Developing risk-based standards for data collection and sharing with construction companies

Mobile Device/Mobile Data Collection

- Developing better ways to verify data and ensure data integrity
- Developing augmented reality to visualize underground utility lines through a mobile phone or tablet
- Creating a mobile excavator app

Ticket Management and Processing

- Uniform handling of tickets
- Data validation
- Standard mark-up language for tickets and damages
- Enhanced positive response—early coordination with utilities before construction
- Facility owner identification—uniquely identify facility owners

Education/Training

- Trenchless Best Practices dissemination via mobile apps
- Vacuum excavation Best Practices dissemination via mobile apps
- Enforcement consistent throughout the country and results in a centralized database
- Connections with stakeholder training programs to existing laws
- Sharing data about the pipeline location—who has access and how is that visualized/displayed
- Training about how to dig with a shovel via videos/apps
- Technology implementation—pilot programs to better deploy and adopt new technologies

Other

- Application of breakaway gas fittings on gas meters for earthquakes
- Applying Internet of Things[1] (IoT) technology to enable intelligent shutoff, remote monitoring and damage detection
- Simultaneous Localization and Mapping (SLAM)
- River crossings—river behavior, sensors to detect erosion and slides that may cause damage
- Harsh environmental impact on polyethylene pipe
- Avoiding creep from constant pressure on polyethylene pipe
- Miniaturization and improvement of quality-of-facility monitoring cameras
- Cross-bore prevention and identification
- Higher powered 400Hz GPR; need FCC approval
- Integration of awareness of ground movement threats during design phase
- Integration of multiple sensors for facility inspection, protection, and monitoring lidar (light detection and ranging), imagery, radar, etc.); data fusion
- Use of drones for collecting data about construction work

Summary of Current Industry Technologies

This section provides basic identification and categorization of current technology in use—it is a snapshot of damage prevention technology for 2017. For questions about a current technology in use or to suggest additions to this catalog, please contact the Technology Committee.

One Call

- Predictive analytic/risk assessment tools
- One call and excavator coordination software

[1] The interconnection via the Internet of computing devices embedded in everyday objects, enabling them to send and receive data.

- Enhanced positive response
- Ticket management and processing
  - Software
  - Web-based
  - Field-based

Locating Technologies

- Electromagnetic
  - Signal distortion detection
    - Increases measured depth accuracy
    - Increases x/y accuracy
  - Ambient interface management—mitigates ambient noise issues
  - High-dynamic range—removes need for gain control
- Magnetic
- Acoustic
- Ground penetrating radar (GPR)
  - Multi-frequency
  - Hand cart
  - Mobile vehicles
  - 3D radar tomography
- RFID markers
- Enhanced passive electromagnetic locating
- Automated flag insertion devices

RFID = Radio Frequency Indication

RTK = Real Time Kinematic

GIS = Geographic Information System

GPS = Global Positioning System

Lidar = Light Detection and Ranging

UAV = Unmanned Aerial Vehicle

GIS/GPS Technologies

- RTK[2] GPS—increased resolution
- GIS/GPS
  - Big data storage and analytics
  - Added satellites
- Geofencing

Utility Mapping

- Increased use of subsurface utility engineering
- Surveying
  - RTK GPS
  - Total stations
  - Lidar of exposed utilities
  - Software to capture and manage data
- RFID markers

Excavation Technologies

- Vacuum excavation—air and water

[2] Real Time Kinematic positioning is a satellite navigation technique used to enhance the precision of position data derived from satellite-based positioning systems.

- GPS encroachment devices on the earth mover
- Asset management
- Ground movement—hazard detection and monitoring
- Software (for mapping, workflow coordination)
- Data collection (location, specific ID, maintenance records)

Imaging Technologies

- UAVs (drones with various sensors)
- Land and aerial lidar surveys
- Satellite imagery
- High-resolution aerial Imaging
- Synthetic aperture radar
- Aerial hyperspectral imaging
- Thermal imaging
- Sensor fusion (the IoT)
- 3D radar tomography
- Data logging devices with imagers and lasers
- Digital photography

Mobile Devices

- Cell phones/tablets
- Data recorders
- Handheld screens used for showing maps

Pipeline Data Acquisition Technologies

- In-line inspections (smart pigs in the pipeline)
- External checks (corrosion testers, locating and mapping the lines, etc.)
- Field crew reports from handheld data capturing devices (loggers, lasers, cell phones, cameras, pads, etc.)
- Environmental change detection analysis (aerial planes, UAV or satellite imagery)
- Encroachment analysis
    - Fiber optic sensors
    - Acoustic sensors
    - Aerial, UAV, and satellites
- Legacy data conversion to GIS
    - Paper records
    - Alignment sheets
    - Memory—human recollection
    - Excel and Access data sheets
- Elevation and cartography data
- GPS/GIS-based data
    - Data to improve emergency responses—pipeline location, area terrain, depth of cover, High Consequence Area (HCA) analytics, etc.
- Mobile lidar surveys for methane leak detection

Increasing Public Awareness Technologies

- Social media
- Regional CGA apps
- Web-based messaging

Technology Related to Managing and Visualizing Data

- Geospatial information system (GIS)
- Building Information Modeling (BIM)
- Computer Aided Design (CAD) software
- Various market-focused software (pipeline/city/construction project management)
- Artificial intelligence and IoT
- Augmented reality/virtual reality/3D visualization

Project Management

- e-Construction—all documents signed and delivered to all parties electronically
- Enhanced GIS software for municipalities

Conclusion

Technology is an important component of damage prevention. As such, it needs to be identified, evaluated, and shared so that anyone involved in protecting underground assets has an opportunity to use that technology for their own regional needs. This report shares the collective knowledge about these technologies with the goal of furthering discussions, improvements and better ways of using them. The CGA Technology Committee will strive to expand upon and improve this annual report for it to serve as almanac of underground damage prevention.

Technology Case Studies

All case studies on new technology are welcomed by the Technology Committee for review and possible inclusion in this report. The goal of the committee is to provide information about technologies that are in different stages of development and that have good potential for making a positive change for damage prevention.

For this inaugural report, the following case studies are presented:

1. Gas Technology Institute: ORFEUS Obstacle Detection System for Horizontal Directional Drilling
2. Gas Technology Institute: Reducing Excavation Damage in the Natural Gas Industry Using Real-Time GIS and Sensors
3. Southern California Gas: Increasing Efficiencies in Pre- and Post-Inspections for Cross Bores

Case Study 1: ORFEUS Obstacle Detection System for Horizontal Directional Drilling

Case Study from: Gas Technology Institute (GTI)

Contact Name: Michael Adamo

Contact Email: michael.adamo@gastechnology.org

Primary Author: Michel Hardy, ENGIE

Primary Author Email: michel.hardy@grtgaz.com

Area of Technology: HDD, Excavation Damage, Safety

Level of Production: Yellow[3]

Horizontal directional drilling (HDD) is a means of installing underground pipes and cables without needing to dig trenches. The method offers numerous advantages over traditional approaches, but requires care, particularly when used in urban areas, because of the risk of damage to existing buried infrastructure. This is mainly due to uncertainty of the location of pipes and other obstacles in the path of the drill head. The European project (VII PCRD) ORFEUS (Operational Radar For Every drill string Under the Street) gathered 11 partners and allowed for the development of a horizontal directional drilling machine with "look ahead" technology, which consists of radar incorporated into the drilling head to detect and warn the operator of obstacles during the drilling operation. The material development phase allowed for the realization of experiments, on-site tests and user input to estimate and validate the technology. The technical limitations, operational implementation and environmental advantages were identified during this phase of the development. The practice and the skills of the end-users were captured as well. During these experiments, more than 500 meters of pipes were installed using this new horizontal "look ahead" drilling. More recently, Operations Technology Development (OTD), in partnership with Gas Technology Institute (GTI), conducted a successful demonstration of this technology at Pacific Gas and Electric's (PGE) training facility in Livermore, Calif.

ORFEUS' successful development of the HDD radar concept offers substantial benefits in worldwide sectors, including Europe and the United States. Such technology allows for enhanced safety, environmental and technical advantages and lower costs of HDD, compared to standard trench-based systems. Further research is being sought for the development and commercialization of the technology. The following items will be addressed: optimization of the radar antenna and its location on the drill head, improvement of the distance and range of detection around the drill pipe ~50cm, improvement of the operator display and real-time alert system, and integration of technology into various original equipment manufacturer (OEM) HDD systems.

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[3] Red – technology being discussed at a level to determine if the manufacture should continue.
Yellow – manufacturer has determined to move forward but is not in full production at this time.
Green – technology is in full production and available for purchase.

Partnership

As described, ORFEUS development and testing involved two different groups of partners:
- U.S. Testing – OTD and GTI
- Consortium funded by European Commission

OSYS technology limited	Osys Technology limited	UK	Coordinator/electronics
	Wellington Associates	UK	Innovation advisory
IDS	IDS	Italy	GPR design and manufacturing
	Tracto Technik (TT)	Germany	Manufacturer of horizontal drilling machine
eNGIe	ENGIE	France	Referrer/end user
eXergia	Exergia	Greece	Communication
Vilkograd	Vilkograd	Slovenia	Civil engineering company
EURAM LIMITED	Euram Ltd	UK	Budget management
	Dublin city	Ireland	Referrer/end user
	J&P Geo	France	Consultant
Florence Engineering	Florence Engineering	Italy	Tilt sensor design

Figure 1: ORFEUS Partnership

Technical achievement

The ORFEUS-developed system consists of:
- A modem to connect the operator's computer to the drill string transmission line
- A power supply to deliver power to the drill string transmission line
- A slip ring system to interface the stationary surface system to the rotating drill string
- Communications module at the drill head
- A modem to connect the radar system to the drill string transmission line
- A unit to receive power transmitted along the drill string and convert it into the various voltages required by the modem and radar system

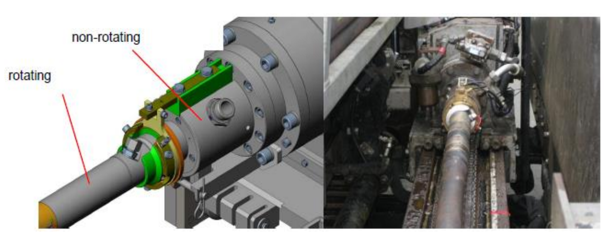


Figure 2. Slip ring schematic and implementation

Figure 3. Drilling machine with slip ring

Demonstration trials

Four demonstrations on in-field test sites were organized in Europe. An additional test site was located in Livermore, CA.

Demonstration on site in Paris (France)

The aim of this trial was to trenchlessly install 75 meters of polyethylene (PE) water pipe using the ORFEUS obstacle detection system. As shown in Figure 4, the environment was very congested with lots of buried pipes that were crossing beneath or above the drill head. Pits were excavated to validate the exact position of the existing infrastructure. Many other unknown obstacles were also present, such as old foundation walls, pipes and other buried items.

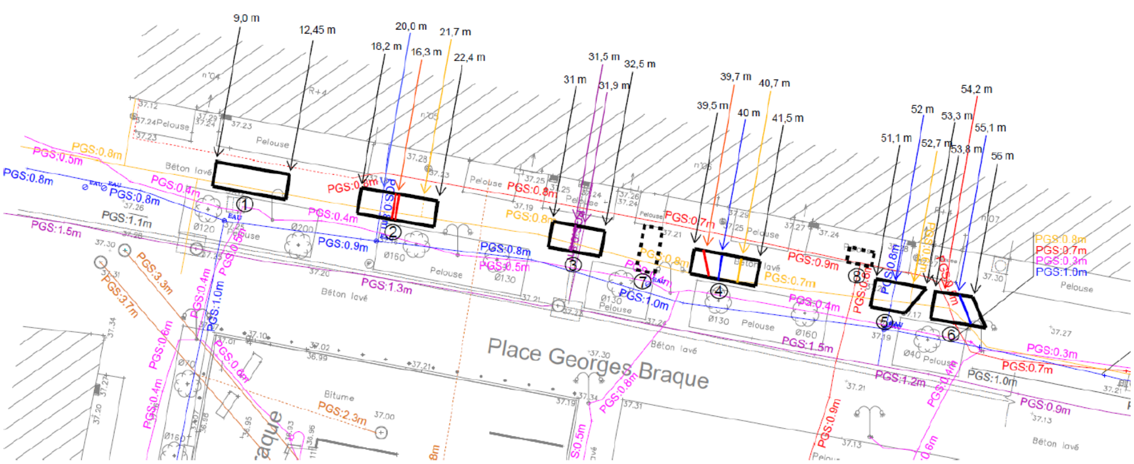


Figure 4. Congested environment for the trial in Paris

During the drilling operation, it had to be stopped because an unknown object was detected by the ORFEUS system. After investigation, a previously unknown electrical cable was found, as shown in Figure 5.

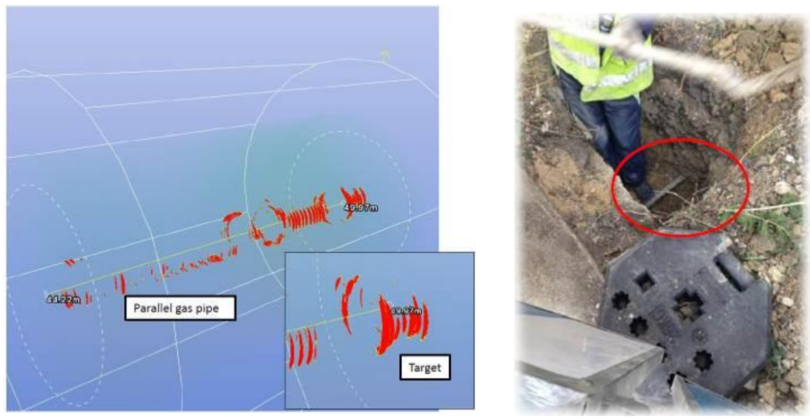


Figure 5. Detection of an unknown obstacle, which was in fact an electric cable

Demonstration on test facilities in Livermore, Calif. (United States)

The construction of a dedicated test site was executed at the PGE training facility in Livermore, Calif. A selection of non-conductive and metallic pipes with different diameters and layout with respect to the planned drilling path had been laid during the period before the trial. In addition, two boulders were also buried in the area, as well as the installation of a “joint trench” in the final part of the test site.

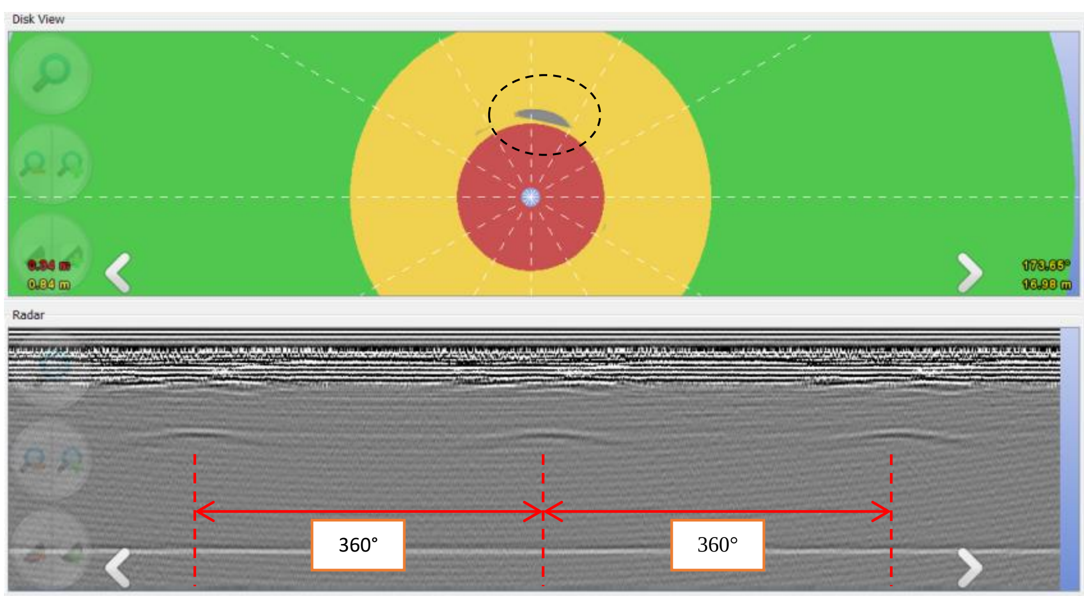


Figure 6: Parallel pipe detection. Software 2-D view and radar view

Conclusions and next steps

Field trials carried out in Europe and United States contributed to an assessment of the risks and confirmed operational viability and performance of the ORFEUS prototype HDD system. This demonstration phase also helped to assess the environmental benefits and to increase end users (such as utilities, public authorities and industry), standardization bodies, and the general public's confidence, awareness and uptake of this new technology. The ORFEUS "look ahead" system is a prototype that could be used with all drilling machines with only a few modifications required.

Further developments of the technology will improve the real-time visualization (e.g., synthetic results after target detection) and the generation of an operator warning alarm when a risk of potential strike is detected.

Funding for these developments is currently being pursued. The future project is intended to raise a Technology Readiness Level[4] to 9 through U.S. and European efforts, with leads by Engie Lab and GTI, to comply with utilities' requirements worldwide. ORFEUS technology could be commercialized and used by utilities within 2.5 years.

[4] Technology readiness levels (TRL) are a method of estimating the maturity of Critical Technology Elements (CTE) of a program during the acquisition process. They are determined during a Technology Readiness Assessment (TRA) that examines program concepts, technology requirements, and demonstrated technology capabilities. TRL are based on a scale from 1 to 9 with 9 being the most mature, meaning actual system proven through successful mission operations.

Case Study 2: Reducing Excavation Damage in the Natural Gas Industry Using Real-Time GIS and Sensors

Case Study from: Gas Technology Institute (GTI)

Contact Name: Robert Marros

Contact Email: Robert.marros@gastechnology.org

Area of Technology: GPS, Excavation Damage, Safety

Level of Production: Yellow

The Gas Technology Institute (GTI) working together with Pacific Gas and Electric (PG&E), was awarded a grant from the California Energy Commission (CEC) in July 2016 to further the implementation of a cloud-based platform designed to reduce or eliminate damage to the gas system due to excavation activity. The GPS Excavation Encroachment Notification (GPS EEN) system was developed using a cutting-edge cloud-based computing platform comprised of real-time GIS IoT sensor platform, machine learning and characterization algorithms.

The CEC-funded project would build and scale the GPS EEN system to deploy 150 devices within the PG&E service territory. The deployment would be coordinated with GTI resources and be primarily facilitated by PG&E. The GPS EEN system has many components that work together to provide actionable information to stakeholders with the primary goal of preventing unintentional dig-ins to the gas system. The main components of the GPS EEN system include:

- Black box device—IoT device containing Global Navigation Satellite System (GNSS)/ (GPS) sensors for positioning, nine degree of freedom (9DoF) sensor to provide orientation, accelerometer and gyroscope data for movement and a cellular modem to transmit data in real-time. The black box device also contains an audible alarm to warn an operator of the presence of a gas main and LED lights for visual warnings.
- Computing platform—Amazon Web Services (AWS)-based computing platform that contains Environmental Systems Research Institute (ESRI) real-time GIS software and machine learning characterization algorithms to determine the status of excavators and backhoes in the field.

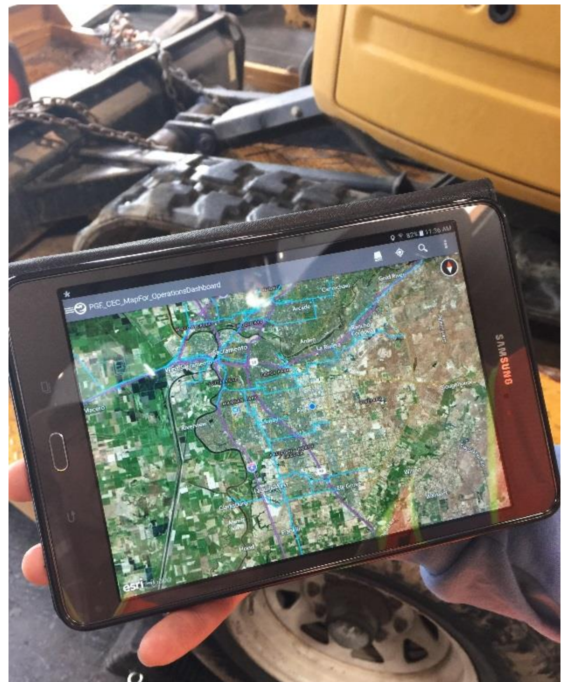
The black box devices were installed on a host of varying equipment including backhoes, excavators, and agricultural equipment. The devices were built to provide continuous monitoring, be easy to install and operate and be resistant to weather conditions. Once the devices are installed on the field equipment, they send location and 9DoF information every five seconds as they move around PG&E's service territory. The 9DoF sensor updates constantly and provides discrete information about the physical movement of the field equipment in the X, Y and Z axes for the gyroscope, orientation and accelerometer. This data is used to understand the physical movement of the field equipment while the GPS/GNSS device provides spatial location information.

Example of field equipment this device might reside in

In order to provide alerts and warnings to the field operator and stakeholders from PG&E, the GPS EEN system utilizes GIS data that contains spatial information about the PG&E transmission mains as an overlay on an aerial image. The GIS data, in conjunction with the location of the equipment in the field, provides a means for analyzing in real-time the proximity of the equipment to the gas system, signaling to the operator using audible and visual alarms that a gas main is near. Two-way communication between the black box device and the computing platform allows the operator to confirm that they received the alarm and silence it.

Device installed in cab of field vehicle

Providing alarms and alerts to field operators and stakeholders is important to prevent dig-ins and also needs to be informative and accurate. GTI developed characterization algorithms to assist in identification and characterization of equipment activities in the field. The development of the characterization algorithm utilizes in-person observations and machine learning to help identify and improve the algorithm's ability to classify activities in the field. The characterization algorithm allows the system to provide more intelligent and actionable information to the field operator without overwhelming the field operator with unnecessary or inaccurate information about the presence of a gas main when the backhoe or excavator is not participating in a digging activity that would present a risk of a dig-in. As different field equipment is observed, that data is used to improve and update the characterization algorithms.



Data visualized on a hand-held tablet.

Data sent from the field equipment is processed by a computing platform built to receive, store, and manage large amounts of real-time data. The AWS platform provides a robust, scalable system to enable the GPS EEN system to function. In addition, this platform is also used to provide visualization capabilities to stakeholders. Visualization of activity within the service territory provides awareness and analytic capabilities to better understand the interaction of excavation equipment with the gas system. Historical data is also captured and stored to provide additional information to review incidents and near-misses.

Within the GIS data that drives the visualization and geospatial analysis portions of the system, GTI collected data from PG&E for the gas transmission mains and created geofences, or buffers, of the gas main. These buffers provided a larger area surrounding the gas main to allow for triggering alarms and alerts before the field equipment was already on top of a gas main. The concept of creating the buffers also serves other purposes because it takes into account the inaccuracy in the GNSS/GPS sensor and that the black box device is typically installed in the cab of the field equipment. The buffer for the project with PG&E was set at 50 feet on either side of the gas main to allow for sufficient area to process and send alerts to warn the operator of a gas main.

The concept of providing a buffer around a gas main also has other potential that was explored through the project with PG&E. For example, creating a project boundary around an area where digging operations are occurring allows for the GPS EEN system to further tailor alerts and warnings and the functionality they provide. Another benefit of the buffer boundary allows for 811 or one call tickets to be added to the system to provide 'safe-areas' for digging provided the ticket was active. Additionally, this same concept could alert stakeholders to digging activity that is occurring within a ticket area that is outside of the allowed ticket time.

The GPS EEN system improves the situational awareness capabilities of PG&E as well as providing equipment operators with a potentially lifesaving device using cutting-edge technology. Combining currently available technology in the form of hardware and software has created a powerful new tool to address one of the leading causes of incidents within the natural gas industry. Excavation damage or dig-ins have the potential to lead to fatalities, serious injury, property damage and/or service disruptions.

Through this project, GTI was able to characterize excavation activity and combine GIS data to provide an accurate algorithm to significantly reduce the occurrence of false-positive results in the characterization of field activity. Working with PG&E, GTI was able to conduct a significant test of the computing platform by deploying 150 devices in PG&E's service territory. The characterization algorithm has been proven to be 80 percent effective in characterizing digging activity and will continue to improve as more training data is collected.

As a result of the successful deployment of the CEC project, GTI is actively working with PG&E to find a company to commercialize the technology and make it available in the marketplace.

Case Study 3: Increasing Efficiencies in Pre- and Post-Inspections for Cross Bores

Case Study From: Southern California Gas

Contact Name: Harley Peterson

Contact Email: hmpeterson@sempra.com

Area of Technology: Cross Bore Mitigation/Inspection

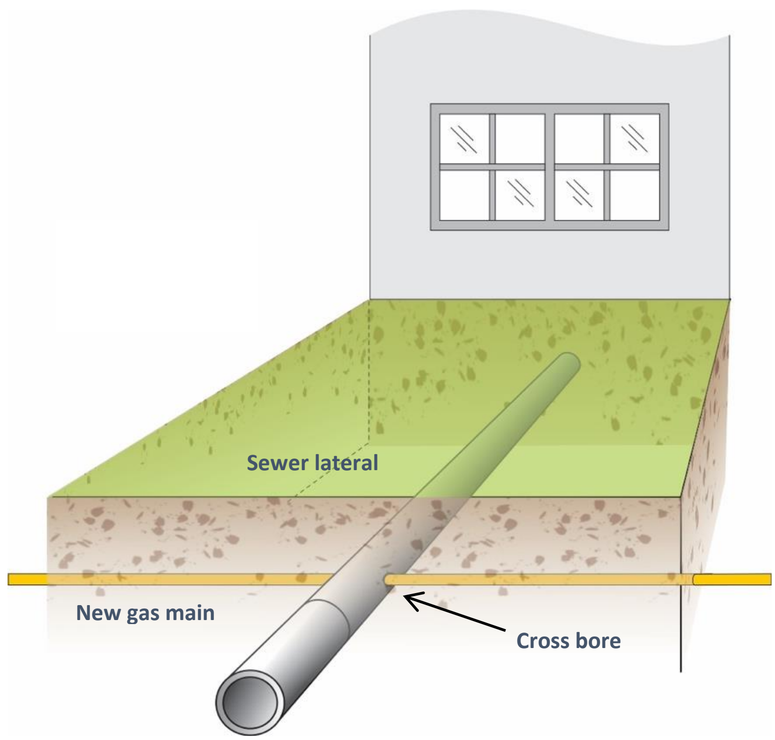
Level of Production: Green

In 2010, Southern California Gas Company (SoCalGas) commenced a long-term program to address the presence of cross bores—a dangerous type of damage that occurs in underground utilities—in southern California. Through its Sewer Lateral Inspection Program (SLIP), SoCalGas has been proactively inspecting all sewer laterals located within its 20,000-mile service territory for cross bores. With every address from the U.S.-Mexico border up to the middle of Fresno, Calif., requiring inspection, SoCalGas has taken steps to use technology and methods that can meet the demands of the program. This article details how SoCalGas inspects for, locates and removes cross bores, reducing the prevalence of these unseen hazards.

What is a cross bore?

A cross bore is an intersection of an underground utility by a second utility that can occur when the new line is installed using horizontal directional drilling (HDD), or horizontal boring. HDD is a growing trenchless utility installation practice that offers multiple benefits over trenching, including reduced project costs, less street disruption, and fewer environmental impacts.

When using HDD, a new line path is drilled into the ground horizontally. Once the path is drilled, the new line is attached to a reamer and then pulled back through the drill hole, setting the line underground. If the reamer breaks through an existing underground line, the resulting intersection of the two lines is known as a cross bore, or intrusion.



Cross bores can happen to any utility when installing a new line with HDD. However, when a sewer lateral is cross bored by a gas main, it creates a hazardous situation that can lay unnoticed for years and worsen over time, according to the Cross Bore Safety Association.[5] If the drain deteriorates, becomes clogged, or leaks—events that are more likely to occur the older the drain becomes—a plumber using a "cutter" to clear the line may inadvertently cut the gas line, releasing natural gas into the sewer lateral. This pressurized gas can then migrate into the home or building, posing an immediate threat to human life and property. Because of the high risk that ruptured cross bores carry, finding and removing cross bores is critical.

How SLIP works

Residential and commercial sewer laterals extend from the property to the city sewer main. While it is the property owner's responsibility to maintain sewer laterals, the laterals are generally only inspected if a problem arises. Therefore, SoCalGas has taken a proactive approach to finding cross bores in sewer laterals with thorough planning. Grids are created and triple-checked to make sure every address with a sewer lateral is inspected.

When SoCalGas began SLIP in 2010, it used two mainline inspection vehicles and four vehicles equipped for push camera inspections.

One of two brands of mainline crawler systems for inspecting the interior of pipelines, IBAK or CUES, are used to find cross bores via the sewer main under the street. The systems crawl down the sewer main and deploy a "lateral launch camera" into the connecting sewer lateral. The launched camera mechanically pushes up into the property's drain, allowing SoCalGas to inspect the lateral back up to the property.

If the lateral launcher cannot inspect the property's drain line sufficiently, SoCalGas uses a RIDGID SeeSnake push camera. The camera is inserted into the property's clean-out or roof vent and then pushed back to the main.

If no signs of cross bores are found, the address is cleared. SoCalGas reviews the inspection footage once more before archiving it in a database. To increase productivity, SoCalGas has purchased more inspection units, currently using four mainline inspection trucks and eight vehicles dedicated to push cameras, plus equipment that its contractors use for the project.

Adapting technology to assist in the search for cross bores

Many of the homes in southern California are approaching the century mark in age, meaning many of SoCalGas' inspections are of older cast-iron laterals. Due to their older fittings and/or corrosion, these

[5] Mark Bruce and Jeff Graham, "Creating High Confidence – Essential Elements for Cross Bore Elimination Projects," *Cross Bore Safety Association* (n.d.): 2.

laterals are often difficult to push a camera through. The lack of front-side clean-outs in these older neighborhoods can also hamper inspections.

In 2013, SoCalGas worked directly with the engineers of the SeeSnake line of diagnostic cameras. The partnership created a new camera technology that could meet the demands of SLIP.

Based on SoCalGas' descriptions of the issues it was facing, SeeSnake engineers created a longer spring assembly as well as a stiffer push cable. Both were housed in the new RIDGID SeeSnake rM200 series as the D2B model. The system uses a one-inch colored, self-leveling camera with a very short body. Behind that is the longer spring that has another spring nested inside. The result is a small camera head with a gradual transition in stiffness before the push cable termination, which allows the camera to negotiate turns farther down the line. Once this system was employed, areas that could only be accessed roughly 15 percent of the time were visited again with a jump to 85 percent or higher. A longer version at 325 feet of this camera system was also created for larger residences and apartment complexes.

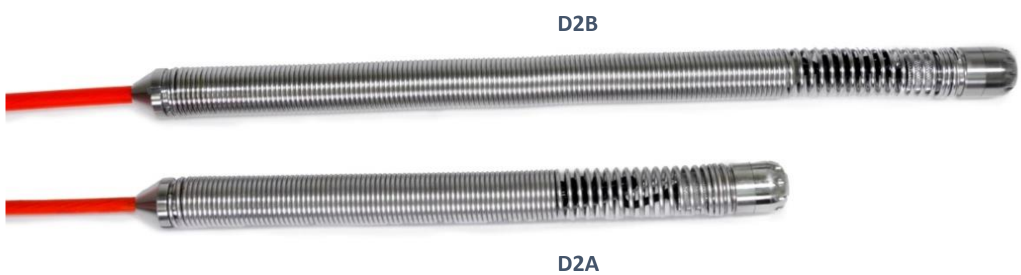


Figure 1: Comparison of the SeeSnake rM200 D2A and D2B spring assemblies

SoCalGas also requested help in improving its ability to pinpoint the location of any cross bores that are found. Once a cross bore has been found, workers use a RIDGID SeekTech SR-20 receiver to find the location of the camera's sonde, which is a remote transmitter installed in the lateral launch and push cable camera heads. According to Harley Peterson of SoCalGas and the SLIP project manager, contractors had been struggling to locate sondes in the lateral launchers using 33 kHz. The signal often couldn't penetrate the cast iron laterals, preventing locators from obtaining accurate horizontal locations and depth readings.

To address this issue, SeeSnake engineers suggested a change to the frequency of the sondes. A much lower frequency, 512 Hz, is easier to trace in cast-iron pipes. IBAK then made the change in its lateral launch cameras. Since it began using the newer cameras with added 512 Hz sondes, SoCalGas has had more success in locating the camera head's position.

Improving efficiencies and looking forward

SoCalGas is dedicated to ongoing safety and has expanded SLIP to include inspections of all laterals before any trenchless gas line installations. Going forward, pre-HDD inspections will be used to find the laterals' horizontal location and depth prior to any boring to reduce the risk of creating more cross bores. Identification of any substructures in the bore path is also part of the process.

As of now, the company is reaching an average of 60,000 post-HDD inspections per year. While the number represents an extensive effort, Peterson explains that being thorough is far more important than speed.

In the course of doing so many inspections, SoCalGas has identified patterns to increase its efficiencies while maintaining quality. For example, cross bores may lie at the upper portion of the lateral or very low at the bottom of the pipe. This requires that they take the time to inspect each line carefully with a focus on those two locations.

Figure 2: What lurks below? Sometimes cross bores go unnoticed for years. These two pictures from SoCal Gas show how high, or how low, the gas line may intersect the pipe, allowing the sewer system to operate normally.

Other efficiencies come from workflow and technology. SoCalGas has partnered with contractors like ProPipe and industry technology suppliers to achieve workflow efficiencies and a below-average cost on each address cleared.

SLIP's success so far serves as an example to other gas providers undertaking similar projects to find and remove cross bores. It is also a testament to the success of partnerships between utility owners, manufacturers and contractors. As more utilities are installed, it will become increasingly important for cooperation between stakeholders to find ways to reduce hazards associated with underground utilities, protecting these critical services and enhancing safety across the nation.