Technology Report 2022

Technology Advancements & Gaps in Underground Safety

VOLUME 5
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July 25, 2022

Dear Damage Prevention Stakeholders,

The Common Ground Alliance is pleased to publish its fifth annual Technology Report. The Technology Committee's work focuses on highlighting innovative ideas and incentivizing the next generation of damage prevention technology**.** The 2022 Technology Report does just that, not only by showcasing exciting new technology applications, integrations and insights with damage prevention stakeholders – but also by underscoring key barriers to more widespread adoption of available solutions. I encourage you to explore the links on the following pages for additional details on featured technologies and share them with your colleagues. CGA has also created a new Technology Hub, where members can explore more in-depth damage prevention technology information year-round.

In both our professional and personal lives, the ever-increasing speed of technology development is truly stunning. In this Report, you will read about case studies submitted to the CGA Technology Committee featuring leading-edge damage prevention technology applications that are driving real-world successes. But you will also read some important insights about challenges to technology integration and adoption within the damage prevention industry that are preventing us from meaningfully driving down the annual rate of damages to buried infrastructure in North America.

A primary theme from CGA's 2021 Report was the gap between the extensive range of existing technologies and the damage prevention industry's utilization of some of those solutions. To meaningfully reduce damages, it will be important for all stakeholders to consider how their investments in technology and technology integration can make a more significant impact on the efficiency and effectiveness of damage prevention.

CGA surveyed damage prevention stakeholders about technology topics and priorities in June 2022, revealing a 43% enthusiasm gap among respondents' ranking of their company/organization's highest priorities when comparing safety and technology/innovation: 73% of respondents indicated safety is the highest priority while 30% indicated technology/innovation is the highest priority. It's important that we consider technology investments and integrations as essential tools for helping us reach our goal of zero damages.

The case studies featured in this year's Report showcase the power of integration, and a key takeaway from both CGA's Next Practices Initiative and this Report is that ensuring our information systems talk to one another can prevent more damages and save more lives. For example, the industry's willingness to share facility map data in particular – and the ability of locating technologies to integrate directly with facility maps – has begun to shift in the last few years, creating a significant opportunity to systemically reduce damages. We look forward to seeing the industry work more collaboratively, with the shared responsibility philosophy of damage prevention at the forefront.

In addition to reading this Report and our 2022 Technology Case Studies, please share it with key stakeholders within your organization. CGA members can also help strengthen our annual Technology Report by joining the Technology Committee or submitting new technologies for the Committee's consideration.

Stay safe,

Sarah K. Magruder Lyle

Sarah K. Magruder Lyle
CGA President and CEO

Introduction

It is difficult to quantify both the substantive impact that technology has already had on damage prevention, and the unrealized potential of technology on damage prevention's most persistent challenges. Now in its fifth year, the **Technology Report's** vision is to become the industry's record of progress and source of inspiration for new technologies *and* new applications of existing technologies in damage prevention. This year's publication includes member input on the state of damage prevention technology, an introduction to CGA's new digital Technology Hub, an outline of current technology barriers and opportunities, and *eight* industry case studies.

Industry case studies provide an opportunity for companies currently deploying new technology to share how they are addressing key damage prevention challenges. Because CGA does not promote or endorse any specific products, companies or vendors, the report focuses 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.

In addition to the five Annual Technology Reports and 17 Annual DIRT Reports, CGA has issued several additional white papers and reports in recent years:

- April 2019, Excavator White Paper: Data-Informed Insights and Recommendations for More Effective Excavator Outreach
- October 2020, Locator White Paper: Insights into Improving the Delivery of Accurate, On-Time Locates
- February 2021, Next Practices Report: Next Practices Initiative: Report to the Industry
- October 2021, Next Practices Report: Pathways to Improving U.S. Damage Prevention

Technology is an area where these damage prevention initiatives and data-driven reports intersect. While still delivering on our original vision and goals, with this fifth annual CGA Technology Report we hope to **connect the dots between technology and the other aspects of the damage prevention industry** – whether it be locating, excavating, one call center operations, etc. – and the role of technology in the quest for zero damages.

Following brief summaries of eight case studies, CGA's 2022 Technology Report speaks to the potential of technology integration and the rapid pace of technological development to address some of the damage prevention industry's intersecting challenges. The Report also reviews documented barriers to the widespread usage of available technologies and identifies a new barrier rooted in conflicting business models and incentives among damage prevention stakeholders.

CGA's Technology Committee concludes its 2022 Report with a reminder to the industry that technological solutions have the power to drive the next drastic reduction in damages to buried utilities if we can share the responsibility of addressing roadblocks.

Annual Technology Survey and Member Input

As part of our goal to make CGA's Technology Report an accurate snapshot of damage prevention technology usage, investment and goals, the Technology Committee solicited feedback from industry stakeholders.

In June 2022, the Technology Committee conducted a survey of CGA members focused on gaining insight into how stakeholders view the current state of damage prevention technology. The survey gathered input on the following:

- Level of priority organizations place on technology
- Technology categories members believe could have the biggest impact on damages
- Technologies that should be included/added to the documentation of current technologies the Committee has compiled
- Topics for future case study consideration

The responses revealed that while a 43% enthusiasm gap exists among respondents' ranking of their company/organization's highest priorities when comparing safety and technology/innovation, there is still a significant amount of momentum in the industry to apply technological solutions to damage prevention – particularly when it comes to efficiencies around locating and mapping.

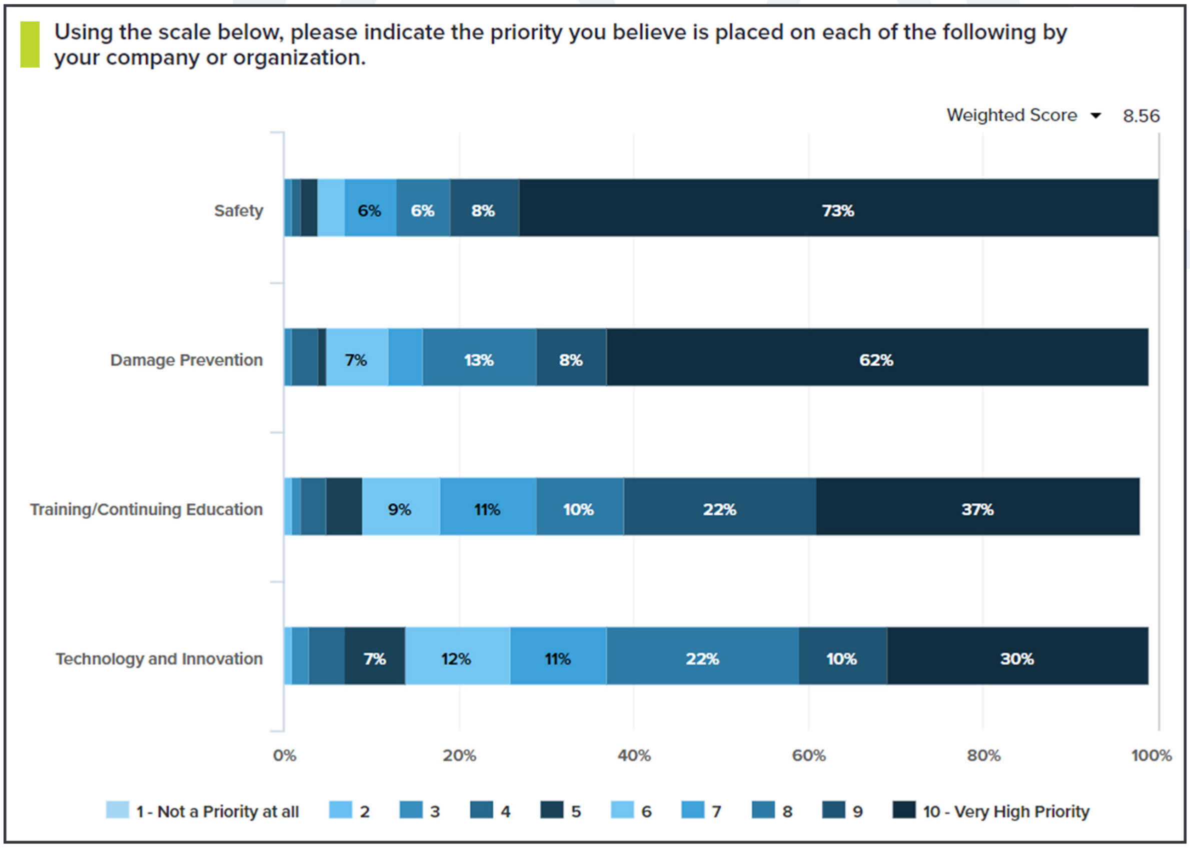

Figure 1

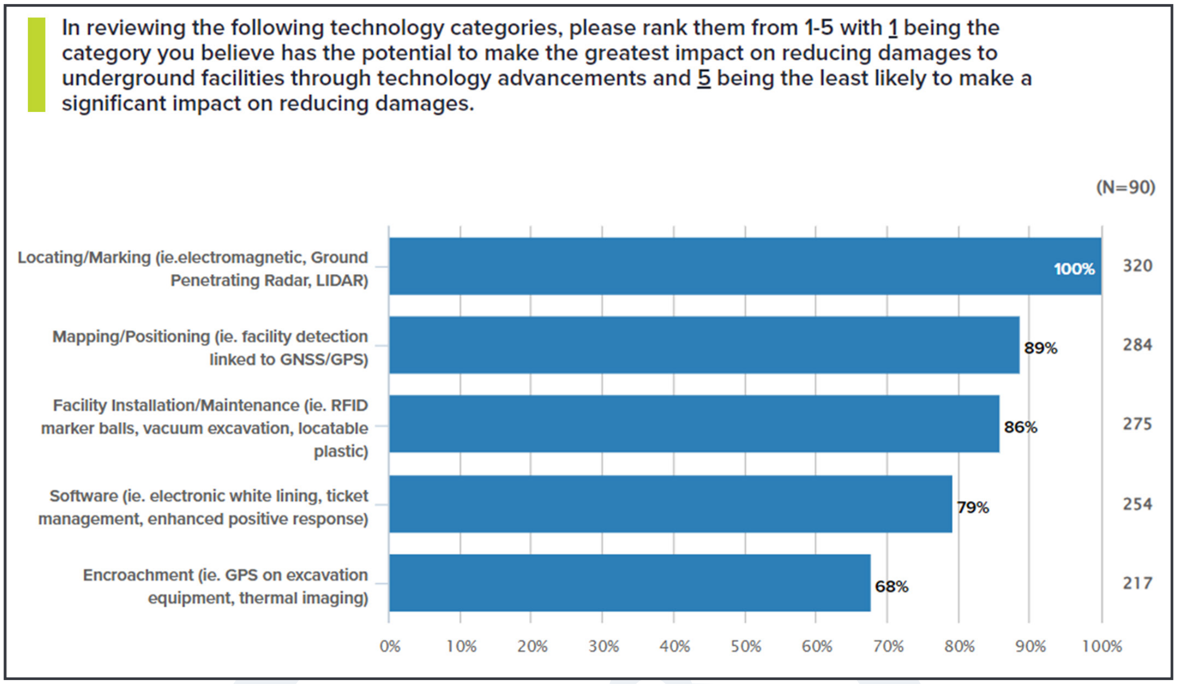

Figure 2

The survey also asked members to review a comprehensive list of technologies that will continue to be monitored and categorized as part of the annual review of damage prevention technology. Some members provided additional suggestions for technologies and/or categories for committee consideration as well as out-of-the box thinking on the future of technology.

Subsurface Utility Engineering (SUE) and Technology

CGA's survey generated significant feedback on the inclusion of (or limited inclusion of) SUE within the Committee's list of current damage prevention technologies. Many responses focused on the need to include SUE as a technology or technology category.

"While a lot of technology is listed in the survey, SUE is the only combination solution because it uses multiple technologies for the project in the planning and design phase. There is not just one technology alone that will improve the process. The use of SUE is critical to cost savings during construction. Technologies are only as good as the practitioner applying them, and standards of care and best practices are essential."

"Please request from a creditable source to have a current SUE study performed. I know of three over the past 20 years and it's time to get a current one performed to continue to show the cost savings to all the stakeholders."

-Annual Technology Survey Response

The Technology Committee did not list SUE as a technology because SUE is defined as a "process" rather than a technology.

CGA's Best Practices Glossary defines SUE as (emphasis added):

> *An engineering **process** for accurately identifying the quality of underground utility information needed for excavation plans and acquiring and managing that level of information during the development of a project*.

However, SUE can provide significant benefits to damage prevention and many technologies can be applied to the SUE process. The SUE process involves quality levels (QL) of increasing accuracy or reliability with two levels essentially corresponding to surface marking (QL-B), locating and potholing (QL-A) – core components of the safe digging process.

Best Practice statement [2.14, Subsurface Utility Engineering (SUE)](), states that "*When applied properly during the design phase, Subsurface Utility Engineering (SUE) provides significant cost and damage-avoidance benefits and the opportunity to correct inaccuracies in existing facility records.*"

Studies in the U.S. and other countries have found positive return on investment (ROI) from using SUE on highway projects, while minimally increasing overall project costs. It appears that the latest study was sponsored by PennDOT in 2012.[1] One of the first was conducted in 1999 by Purdue University and commissioned by the Federal Highway Administration (FHWA). Based on 71 projects from four states (North Carolina, Ohio, Texas and Virginia), the study calculated an ROI of $4.62 for every dollar spent on SUE on highway construction projects. A reanalysis several years later produced a revised ROI estimate of $12.23.

In this year's Report, there are a variety of technologies listed that can be applied to the SUE process. Additionally, some of the Report's case studies highlight these technologies. Two in this year's Report, Exodigo and KCI, specifically mention SUE. Two other case studies, Skipper and ULC, do not mention SUE but have potential for SUE applications.

The Technology Committee recognizes the importance of SUE and welcomes case studies focused on technology that can be applied to SUE. In addition, the new digital Technology Hub discussed below will enable searching for key terms and phrases such as SUE.

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1 Source: Between the Poles blog by Geoff Zeiss. https://geospatial.blogs.com/geospatial/2020/03/large-roi-from-subsurface-utility-engineering-sue-for-highway-construction-projects.html

New Technology Hub and Digital Resource

This year's Technology Report features the rollout of a new Technology Hub focused on providing enhanced access to information describing damage prevention technologies. The new searchable microsite of CGA Technology Reports, case studies and other information is modeled after CGA's online Best Practices. Within the new Technology Hub, case studies will identify the stakeholder group(s) the technology is intended for, using the same icons used in CGA's Best Practices Guide (see below).

The site will also give users the ability to search and filter by stakeholder, as well as key terms and phrases. Many case studies will fit multiple stakeholder groups and categories. This new hub will allow stakeholders to quickly identify the technologies and case studies of greatest relevance to them. It will also provide more visibility and access to the case studies beyond the initial publication of the annual Technology Reports.

CGA members and industry stakeholders can access the content at technology.commongroundalliance.com.

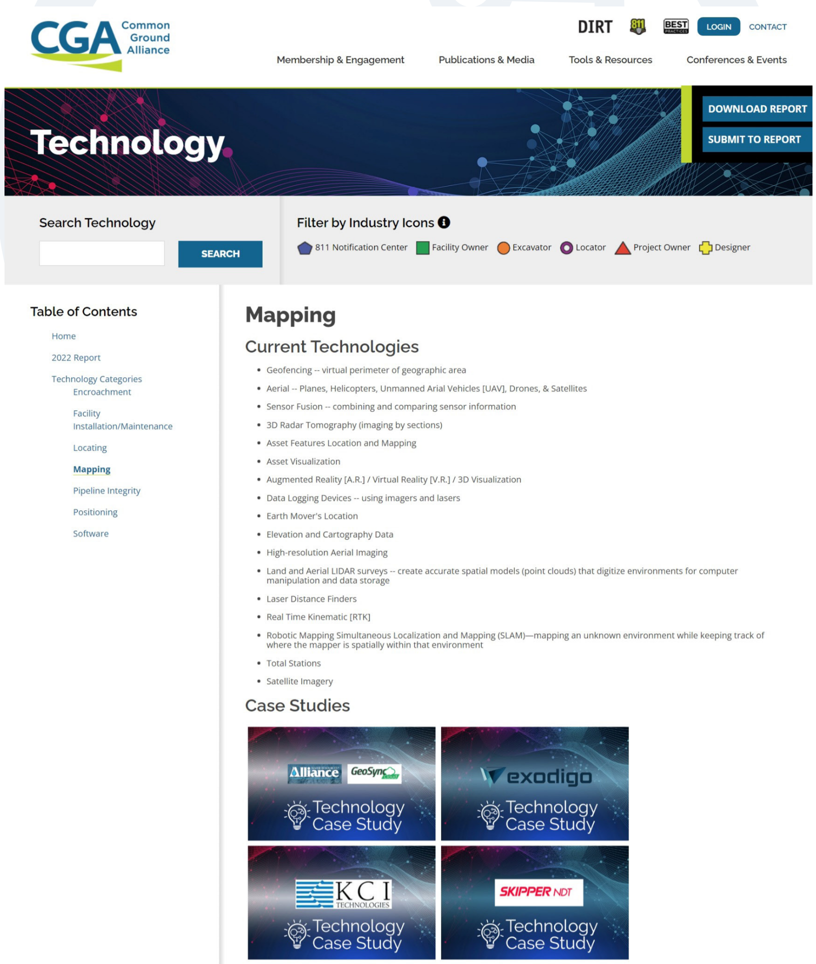
CGA's digital damage prevention Technology Hub also classifies information into seven categories:

- **Encroachment** – Detection of when/where excavation activity is getting close to buried lines. Examples include geo-fencing, thermal imaging, vacuum excavation.
- **Facility Installation** – Reducing chance of damage to other buried utilities during installation or making new facilities locatable. Examples include slot trenching, RFID tags, marker balls, coated/embedded tracer wire in plastic pipe.
- **Locating** – Equipment, techniques and training. Examples include electromagnetic, RFID, GPR, Sondes.
- **Mapping** – Increased accuracy, accessibility, and/or reducing cost or time to complete mapping, etc. Examples include LIDAR, RTK, GNSS, SLAM.
- **Pipeline Integrity** – Maintaining pipeline integrity, including detection and mitigation of cross bores.
- **Positioning** – Incorporating GPS/GNSS satellites to identify the position of buried lines and/or other items such as excavation equipment, locating devices, persons, vehicles, etc.
- **Software** – Incorporating software to enable digital collection, storage and sharing of data, use on mobile devices, desktops, etc. Examples include artificial intelligence, risk assessments, electronic white-lining, data collection, enhanced positive response.

2022 Case Studies

This year's Report includes eight case studies focused on damage prevention technology. The following pages include a synopsis of each case study highlighting key pieces of information, a brief summary of the technology and a link to the full case study on [CGA's digital Technology Hub.](#) The case studies featured in the report include:

1. 811 Spotter Streamlines the 811 Ticketing Process for Excavators
2. KCI Technologies – ProStar PointMan Solution
3. Peoples Gas / North Shore Gas – Ultra-High Frequency EM Safety Sweep and its Effect on Damage Prevention
4. Exodigo, Inc. – Introducing Non-Intrusive Subsurface Mapping
5. ULC Technologies – Improving Underground Locating and Surveying Using a Robotic Vehicle
6. Alliance Water Resources, Inc., of Columbia, MO / Public Water Supply District #6 of Clay County, MO – QGIS Water Mains and Services Mapping
7. Skipper NDT – Drone Enabled High Precision Magnetic Mapping Technology for Buried Pipelines
8. Hammerhead – SAME PATH Trenchless Technology



Level of Production Guide

Where applicable, we use three "levels of production" to indicate the status of a technology:

- 🔴 – *being discussed at a level to determine if the manufacturer should continue*
- 🟡 – *manufacturer has determined to move forward, but is not in full production at this time*
- 🟢 – *in full production and available for purchase*

811 Spotter Streamlines the 811 Ticketing Process for Excavators

811spotter

Snapshot

Company Name(s): 811spotter.com, MGE Underground, McGuire and Hester, Q&D Construction Company
Website: https://811spotter.com/
Technology Category: Software
Key terms/Phrases: ticket management, status, expiration date, positive response
Stakeholder Target Audience: Excavator
Production Level:
[technology is in full production and available for purchase]

To contact case study author, email technology@commongroundalliance.com.

Synopsis

In the multi-stakeholder 811 ticket ecosystem, protecting underground utility infrastructure requires each participant to use tools optimized for their business and role. For excavators, 811spotter improves internal processes and reduces costs while advancing outcomes for all stakeholders. 811spotter is a new 811 ticket management system designed for professional excavators. It combines organization, automation, and push notifications for instant visibility into ticket information, utility member responses, and documentation. This case study presents three companies that achieved positive business, safety, and damage prevention outcomes by integrating 811spotter into their daily operations.

By organizing and automating ticket management processes for excavators, 811spotter provides a range of excavating contractors with greater visibility into ticket information, utility member responses and excavation-centric documentation. 811spotter is currently deployed at 60 companies across California and Nevada (and is up-to-date with each state's current regulations) and is actively expanding to additional states.

Tangible benefits by case study participants

Benefits realized by MGE Underground:

- An average of 2,500 active monthly tickets under management
- Automated ticket system complements the work of three employees
- Yearly operational savings above $200k

Benefits realized by McGuire and Hester:

- An average of 200 active monthly tickets under management
- More time to focus on ensuring compliance with safety and damage prevention processes
- The 811 process custodian can take vacation time without having to meticulously plan a temporary "hand-over" to another employee

Benefits realized by Q&D Construction:

- An average of 200 active monthly tickets under management
- Improved visibility into dig ticket interaction in the field
- Dual compliance with California and Nevada digs laws

Read Full Case Study

KCI Technologies – ProStar PointMan Solution

Snapshot

Company Name(s): KCI Technologies, ProStar PointMan Solution
Website(s): https://www.kci.com; https://www.prostarcorp.com
Area of Technology: Locating, Mapping, Software
Stakeholder Target Audience: Designer, Facility Operator, Locator
Key terms /phrases: data capture, field Sketch, GNSS, locating, software, subsurface utilities engineering (SUE)
Level of Production:
[technology is in full production and available for purchase]

To contact case study author, email technology@commongroundalliance.com.

Synopsis

KCI adopted PointMan after conducting research into acquiring a system designed to effectively capture field sketches. Typically, field notes were either hand-drawn or CAD sketches, all based on visual field references. Best practices in Subsurface Utility Engineering (SUE) enables users to capture accurate GNSS locations and be able to capture accuracy and position metadata. The use of the custom data dictionary real-time data collection allows for quicker and reliable data capture as well as faster, more accurate record keeping, and helps clients reduce costs while giving a reliable data set with the ability to look through previous projects and compare data.

- ProStar and KCI implemented a modern cloud and mobile utility mapping solution to improve the collection, storage, and visualization of survey-grade utility location information, and to provide a real-time automated bi-directional exchange of data between the field data collection devices and KCI's existing GIS and CAD.
- The ProStar Solution consists of two tightly integrated software products – a desktop application called PointMan® that is on the cloud and used to manage and display the data, and a mobile data collection and display application.
- KCI's field validation showed two main areas of improvement and efficiency: geospatial improvements including accuracy of one call data and reduction of construction delays; and cost reduction through fewer line strikes, ability to inform crews of real-time changes, and more.
- PointMan has increased KCI's field productivity by 1.5 hours to 7.5 hours of field productivity per day, yielding a potential productivity gain of $7,800 over 6 months for each locate field crew.

Read Full Case Study

Ultra-High Frequency EM Safety Sweep and its Effect on Damage Prevention

PEOPLES GAS®

We Keep Life Moving

Snapshot

Company Name(s): Peoples Gas, North Shore Gas
Company Webiste: peoplesgasdelivery.com/ northshoregasdelivery.com/
Technology Category: Locating
Stakeholder Target Audience: Facility Owner, Locator, Excavator
Key terms /phrases: difficult to locate, unmarked, high frequency, safety sweep, training, unlocatable, unmarked
Level of Production:
[technology is in full production and available for purchase]

To contact case study author email technology@commongroundalliance.com

Synopsis

This case study describes an on-site utility sweeping technique to find difficult-to-locate facilities such as cast or ductile iron with electrically resistive joints, damaged tracer wire or tape, short side services, and old or abandoned lines. It can also be used to verify existing locate marks prior to excavation. The technique uses locating equipment that is currently available and easy to learn and use. The technique led to significant reductions in damages by in-house crews.

- Following a non-injury strike to a high-voltage power line in 2010, Peoples Gas sought a solution that would reduce damages to all lines, with an emphasis on unmarked lines, as well as verify existing locate marks prior to excavation.
- The resulting solution has three parts: the technology (ultra-high frequency EM locator), the technique (the safety sweep, highly effective in finding unmarked lines), and the training (both in the classroom and the field).
- Peoples Gas realized a decrease in damages of 67% from its in-house crews using this new solution, and a 77% decrease in damages with the root cause of "Facility Not Marked" between 2016-2019.

Read Full Case Study

Introducing Non-Intrusive Subsurface Mapping

exodigo

Snapshot

Company Name(s): Exodigo, Inc.
Website(s): https://www.exodigo.com/
Technology Categories: Locating, Mapping, Positioning, Software
Stakeholder Target Audience: Designer, Facility Owner
Key terms /phrases: 3D map, abandoned line, AI, AutoCAD, BIM, GIS, GNSS, LIDAR, multi-sensor, pothole, SUE, unexpected utilities
Level of Production:
[technology is in full production and available for purchase]

To contact case study author email technology@commongroundalliance.com

Synopsis

This non-intrustive mapping technology deploys multiple sensors and AI – an approach akin to combining an MRI, a CT scan and an Ultrasound – to provide a 3D mapping of buried assets. Building a clear picture from complex data provides stakeholders the critical information they need to help prevent damages.

- Exodigo's non-intrusive subsurface mapping leverages multi-sensing, artificial intelligence (AI), satellites, drones and carts to create digitally geolocated 3D maps of underground facilities that can be integrated into any existing software, including GIS, AutoCAD or BIM (Building Information Modeling).
- Exodigo's AI analyzes signals detected from multiple sensors via satellites, drones and land carts to build a clear picture of subterranean environments, ultimately producing a geolocated file with multiple GNSS layers.
- Non-instrusive subsurface mapping is anticipated to produce better, faster maps of underground environments at scale. It can be used to achieve Quality Level (QL) B in SUE projects, and reduce the potholing necessary to get to QL-A. To date, potholing has been reduced up to 50% on projects located in Israel, and reduced by 70% in Exodigo's first project in the U.S. In addition, that method finds 20-50% more utilities (abandoned and live), as it removes the human bias and live interpretation in the field. The AI software finds all lines in the area, reducing issues caused by abandoned lines.

Read Full Case Study

Improving Underground Surveying and Locating Using a Robotic Vehicle

ULC TECHNOLOGIES

Snapshot

Company Name(s): ULC Technologies, LLC
Company Website: https://ulctechnologies.com/
Technology Categories: Locating, Mapping, Positioning
Stakeholder Target Audience: Designer, Facility Owner
Key terms /phrases: GPR, GPR technician, low-reflectivity targets, plastic pipe detection, robotic vehicle
Level of Production:
[technology being discussed at a level to determine if the manufacture should continue]

To contact case study author email technology@commongroundalliance.com

Synopsis

For many years, Ground Penetrating Radar (GPR) has been used by utility locators to detect underground pipes. With the increasing amount of buried plastic pipe going into congested subspaces, locating is becoming more challenging since plastic offers lower reflectivity compared to metal. ULC Technologies received co-funding from the U.S. DOT Pipeline and Hazardous Materials Safety Administration (PHMSA) to develop a robotic solution to improve the detection of plastic pipes. Because GPR technicians are not easy to find, electromagnetic locating is sometimes preferred over GPR even though GPR may provide better performance. Also, the lack of skilled technicians can cause significant delays in generating reports when using GPR.

The prototype Robotic Underground Survey System (RUSS) is a semi-autonomous system that assists crews in locating and surveying underground infrastructure to build accurate maps of buried pipelines and cables. The robot employs conventional GPR but uses an innovative approach to improve the sensitivity to both metallic and non-metallic pipes. It uses a non-conventional scanning method (known as multi-static data collection or the separation of transmitter and receiver antennas during scanning) and algorithms that improve the detection of low-reflectivity targets.

Read Full Case Study

QGIS Water Mains and Services Mapping and the Collaboration between Public Water Supply District #6 of Clay County, MO and Alliance Water Resources, Inc., of Columbia, MO

Snapshot

Company Name(s): Alliance Water Resources, Inc.; Public Water Supply District #6 of Clay County, MO; CDP Engineers/Mapsync
Website(s): https://www.mapsync.com/; https://www.info.geosync.cloud/; https://alliancewater.com/
Technology Categories: Locating, Mapping, Software
Stakeholder Target Audience: Facility Owner
Key terms /phrases: asset management, GIS, open-source, software, ticket screening
Level of Production:
[manufacturer has determined to move forward but is not in full production at this time]

To contact case study author email technology@commongroundalliance.com

Synopsis

Many small communities struggle with the cost of starting a GIS program. By using open-source GIS and standard processes for collecting and managing data, costs and implementation time are significantly reduced. This case study discusses how a public water district uses GIS asset management tools and services to provide a standardized, scalable asset management solution, enabling them to provide more accurate information to the One Call Center in order to better filter tickets they do not need to receive.

- A collaborative relationship between Public Water Supply District #6 of Clay County, MO, Alliance Water Resources and consultant CDP Engineers/MapSync resulted in the development of a cost-effective GIS program to minimize damages to the District's underground facilities.
- Utilizing a GeoSync app available to smartphones, the District locates assets with handheld GPS units and manages them via GeoSync's app and/or desktop computers through customized data collection forms.

Implementation has produced high-quality initial results in providing better information to Missouri One Call to enhance the field operations of excavators and reduce costs, as well as other useful information including water usage patterns and trends, maintenance, leak history and more.

Read Full Case Study

Drone-Enabled, High-Precision Magnetic Mapping Technology for Buried Pipelines

SKIPPER NDT

Snapshot

Company Name(s): Skipper NDT
Company Website: https://skipperndt.com
Technology Category: Locating , Mapping, Pipeline integrity, Positioning
Stakeholder Target Audience: Designer, Facility Owner, Locator
Key terms /phrases: drone, difficult terrain, locating, magnetism, UAV
Level of Production:
[technology is in full production and available for purchase]

To contact case study author email technology@commongroundalliance.com

Synopsis

Following several years of R&D supported by major utility and energy companies along with leading research labs, Skipper NDT has developed a technology to map buried metallic pipelines using a unmanned aerial vehicle (UAV). The innovation is based on the physical principle of magnetism combined with a powerful suite of patented algorithms to determine, within an inch precision, the 3D position of buried structures in addition to their depth of cover. Several proprietary patented algorithms process different parts of the magnetic spectrum on the right-of-way to provide a precise positioning of the pipeline. It can be especially useful in environments where on-the-ground mobility is a challenge such as rivers, rocky and/or steep slopes.

- Skipper NDT's solution consists of a UAV-agnostic hardware system and software that filters noise from magnetic field data, automatically acquire and process magnetic information, and then utilizes an algorithm to deliver precise pipeline positioning information.
- The pipeline geolocation technology is particularly helpful for troublesome environments, such as rivers and mountainous slopes, and in test cases was able to reveal an abandoned facility and compromised pipeline mechanical structures.
- Field applications also include out-of-straightness assessment in case of geohazard events.
- The Skipper NDT technology was validated by major operators under various configurations. Facility diameters ranged from 3 to 47 inches and included bends and elbows, different soil types, and pipeline products (water, oil, gas).

Read Full Case Study

SAME PATH Trenchless Technology

Snapshot

Company Name(s): Hammerhead Trenchless
Company Website: hammerheadtrenchless.com/
Technology Category: Facility Installation
Stakeholder Target Audience: Designer, Facility Owner
Key terms /phrases: abandoned facility, existing conduit, extraction, same path, trenchless
Level of Production:
[technology is in full production and available for purchase]

To contact case study author email technology@commongroundalliance.com

Synopsis

Gas utility owners have been proactively identifying and addressing pipelines in need of replacement, and some have realized the benefits of trenchless technologies within their pipeline rehabilitation and replacement programs. Reduced excavation is often more economical and less disruptive to utility customers, and utilizing the existing conduit greatly reduces the risks associated with relocating the line. Replacing pipe in the same location eliminates future locating mistakes due to abandoned facilities.

- Following HammerHead Trenchless' success using a "Same Path" pipe slitting/ splitting technology (see Case Study 5 from the 2019 CGA Technology Report), a large North American gas utility approached them for a solution to replace numerous steel services, leading to the development of the SLX 1300 for copper and steel pipe extraction.
- The extractor product was designed specifically for gas utilities to provide them with the cost-savings of 'low-dig' construction methods, the advantages of Same Path technology, and the efficiency to address multiple services in a given time frame.
- The extractor unit requires a pit approximately 4' by 4' in size, located where the service connects to the main. The unit is lowered into the pit and connected to the hydraulic power pack at the surface from which it is operated. A cable is fed through the existing steel service from the machine to another access point. As the steel pipe and cable are extracted, the new pipe is being pulled into place in one seamless motion and extracted pipe can be cut using shears located on the extractor.

Read Full Case Study

Power of Technology Integration

One of the greatest challenges in implementing new technology is successfully integrating it into a single product or process. Several of this year's case studies provide examples of incorporating multiple technology categories into one product.

The following case studies from this year's Report as well as several from past reports utilize a combination of the Locating, Mapping, Positioning and Software technologies:

- KCI Technologies
- Exodigo
- ULC Technologies
- Skipper NDT
- Sawback Technologies (2021)
- Unearth Technologies (2021)
- Leica Geosystems (2020)
- Condux International (2019)
- Bernsten International (2019)
- SeeScan (2019)

They involve various combinations of locating technologies (electromagnetic, GPR, LIDAR, etc.) and platforms (hand-held, ground vehicle, drone) that can be used to locate facilities, map them via GPS/GNSS, or do both simultaneously. As one respondent to CGA's June 2022 damage prevention technology survey stated:

> ***"We believe the biggest opportunity is not either/or (e.g., mapping/software or locating/maintenance) but making these technologies work together."***
> ***-Annual Technology Survey Response***

As seen in Figure 2, survey respondents identified locating/marking and mapping/positioning as the technologies with the most potential to reduce damages. As indicated by the current and past case studies listed above, the technologies combining these features are rapidly advancing. Integrating technologies can make processes more efficient, less expensive, more accurate and safer for all parties. The barriers to adoption are not so much technological but lie elsewhere.

Technology Opportunities, aka Gaps in Damage Prevention

Each year, the Technology Committee identifies **gaps** in damage prevention technology. These gaps illustrate opportunities for technology development—a **wish list of technology innovations to improve damage prevention to inspire stakeholders to innovate and create novel solutions. This year's "wish list" includes the following:**

Encroachment

- Detecting and combining systems of excavation encroachment on pipelines or activity close to facilities/assets (cameras and fiber optic).

Locating

- Locating non-metallic lines.
- Locating and tracking abandoned facilities.
- Mitigating signal bleed-over to non-target lines.
- Updating GIS databases of record with accurate data of as buried during locate.

Positioning

- Mapping near misses and damage locations – collecting and enabling data sharing.
- Providing positional data of current and abandoned facilities via "open" GIS systems or other centralized databases.
- Mapping sewer assets through mainline inspections and associating location in the pipe with video of pipe condition.
- Providing better GNSS signal strength in urban canyons and under tree cover.

Software

- Providing continued analysis of root causes of damages.
- Predictive analytics/risk assessment to delay/clear low-risk tickets during volume spikes.

Barriers to Adoption of New Technologies

Addressing technology gaps is made more difficult by persistent obstacles. CGA has published multiple reports in recent years that outline key barriers to addressing some of the most pressing damage prevention challenges, many of which include barriers in data integration, data portability and other technology-driven issues.

Inaccurate maps and gaps in GIS-mapping systems were a specific area of focus in both the Locator White Paper and Next Practices Report. The Locator White Paper published in 2021 focused on outdated/inaccurate maps as one of the top challenges to accurate and on-time locating, and updated maps as one of the top leading actions for improvement. Along the same lines, the Next Practices Report to the Industry listed a GIS-based mapping system/ database as an opportunity for systemic improvement, stating "*a comprehensive national GIS map of buried infrastructure would make the locating process drastically more efficient and accurate, and identify abandoned facilities.*"

The Next Practices Status Report identified the following barriers to creating and/or sharing GIS facility maps:

- **Lack of willingness to share information:** Whether related to competitive, security or liability concerns, there is not a strong industry focus on sharing highly accurate facility location information across stakeholder groups. In some instances, an organization may begin the structural and technical processes only to have the effort paused when leadership changes.
- **Upfront costs:** Initial investments in GIS technology (mapping, software and hardware) and staff (GIS specialists) can be significant, although they are likely to lead to overall financial efficiencies and reduction of costs over the life of a project.
- **Technology development:** Seamlessly and automatically sharing GIS facility location data across organizations would require the development of an API to aggregate that information. Additionally, there is a need to develop a data portability standard for facility location data in general, and from locating devices to base maps in particular.
- **Lack of centralized body or stakeholder to own/operate a national GIS database:** Without a trusted organization to maintain and manage access to a comprehensive database of sensitive facility location information, the damage prevention industry is unable to responsibly centralize this data in a way that would eliminate inefficiencies.

Conflicting Business Incentives

In taking a closer look, the Technology Committee highlighted "conflicting business models and incentives" as an additional barrier to the adoption of combined locating-mapping technologies. Whether in-house or contracted, the objective for locators is to complete markouts for pending excavation work, subject to timelines in state regulations, and move on to the next worksite. Although combining mapping with locating would have long-term benefits for the facility owner, there could be short-term costs for locators in the form of additional time per locate.

The locating industry already has well-documented challenges in keeping up with demand for on-time locating. This leads to questions of who makes the investment in the technology and who covers the cost of added time in the field. These technologies can make the process of combining locating and mapping faster and cheaper, but at present they seem best suited to niche uses such as complex locating situations, SUE/design projects and privately-owned facilities, rather than day-to-day utility locating.

Other real or perceived barriers to adoption of new technologies include:

- **Resistance to change:** This is the way we've always done it, and we need to protect our turf.
- **Vested interests:** This could lead to our business becoming obsolete.
- **Wait and see:** Let others go first and demonstrate success before we try it.
- **Lack of understanding of the technology.**
- **Wedded to already-approved programs**: Need approvals, budget, contracts and coordination with other departments.
- **Need to prove return on investment.**
- **Regulatory:** It may conflict with state or federal regulations (which may be outdated).

It is past time to advance the pace of technology adoption, application and integration in U.S. damage prevention. The technologies to help us achieve zero damages exist. The barriers facing the industry are not technological. They are driven by financial assessments that do not take into consideration the long-term benefits of investing up front, along with political and institutional challenges. Leaders in damage prevention must prioritize strategic technology investments in order to meaningfully advance the industry.

Pace of Technology Innovation

The speed of technology adoption and implementation continues to be both an opportunity and barrier when considering the future of damage prevention. Many applicable technologies exist, and are used in other industries, but have not been funded fully and/or adopted widely in the damage prevention industry due to a variety of factors.

The damage prevention industry is not alone in confronting this challenge and can look to other industries for perspective, reflection and inspiration in considering the future of damage prevention technology. One well-documented theory known as "Moore's Law" states that while we can expect the speed and capability of our computers to increase exponentially every couple of years, the cost will continue to decrease over time. Although some variations exist in the how this theory applies, it has largely played out as Moore described.

One way to illustrate this concept is to look at the cost of computer hardware per floating points of operation per second (FLOPS) which is a measure of computer performance. Figure 3 below shows the hardware cost per GFLOPS (adding "G" for "giga") over time in constant 2021 dollars.

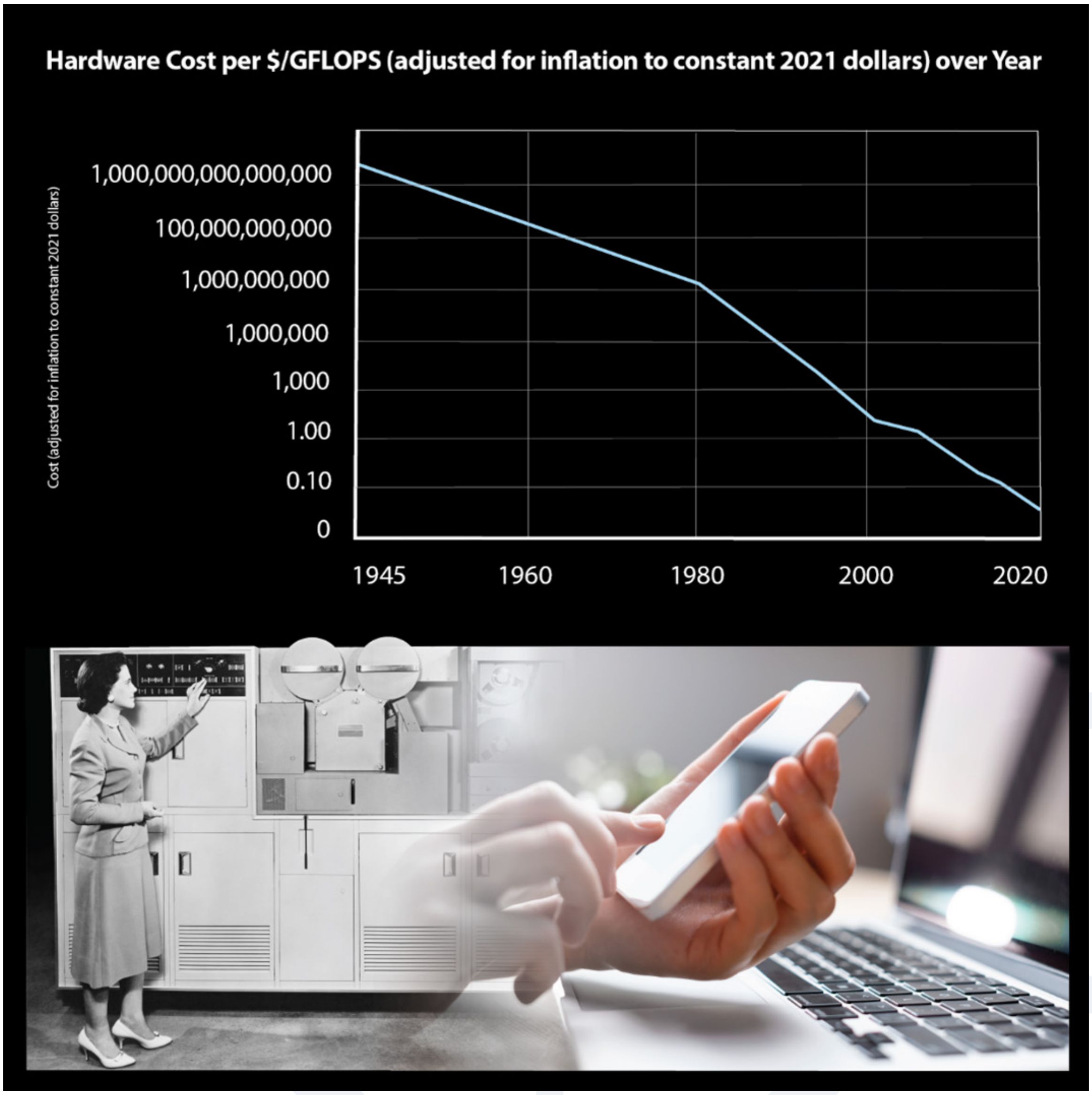


Figure 3 – Hardware cost per GFLOPS over time

The general concept of Moore's law can be seen when looking at damage prevention technology implementation over time. The industry continues to see more compact electromagnetic locating devices with more powerful features. Most 811 centers now receive the majority of their incoming notices electronically rather than by telephone and can support electronic white-lining and automated/enhanced positive response systems. Powerful computing devices can now be carried in our pockets, and we can connect to satellites and map our location in real time with the ability to transfer information almost immediately.

Recent technology advancements are also allowing for enhanced features in buried facility detection and mapping hardware. Hardware can now be mounted on drones and land-based vehicles and can interact with GPS/GNSS satellites to pinpoint the location of buried utilities. This includes finding abandoned lines which are a vexing issue in the industry.

A respondent to the June 2022 survey suggested the following:

> ***"A futuristic (outside the box) thought would be to invent / develop a drone / smart pothole device that could automatically excavate using (vacuum or digging equipment) that uses the latest type sensors (thermal, GPR, etc.) that would slowly unearth soil / asphalt, etc...to expose underground utility lines and would not damage them. Think of it as Star Trek in the 70's... who would have ever imagined we'd have smart phones 40 + years later."***
>
> ***-Annual Technology Survey Response***

Yes, that would be fantastic. Technology continues to evolve rapidly, and implementation costs will continue to decrease. As stakeholders look to the future, it is important to consider that some technology advancements may be closer and more accessible than they appear.

Conclusion

Technology is a critical component of the damage prevention industry and has the **potential to be a primary driver in greater efficiency and improved safety outcomes.** The pace of advancements is accelerating as the technologies become more accurate and powerful while costs and the physical bulk of platforms decline.

The real challenges lie in overcoming barriers to adoption and finding ways to integrate the technologies into the damage prevention ecosystem. The Technology Committee's role is to spread the word about the technologies. In this report we've attempted to demonstrate the possibilities that technology advancements can produce, while being clear-eyed about the barriers to adoption.

Appendix A: Glossary of Terms and Definitions

Acoustic Sensors – A sensor that passively detects and utilizes the presence of sound to locate that sound.

Aerial hyperspectral imaging – Information that is invisible to the human eye, e.g., methane gas leaks, etc. is captured via hyperspectral images.

Ambient Noise Reduction – Active noise control (ANC), also known as noise cancellation (NC), or active noise reduction (ANR), is a method for reducing unwanted sound by the addition of a second sound specifically designed to cancel the first which helps isolate specific harmonics when performing certain utility locates.

Artificial Intelligence (AI) – Simulation of human intelligence in machines that are programmed to think like humans and mimic their actions. The term may also be applied to any machine that exhibits traits associated with a human mind such as learning and problem-solving.

Data Visualization – The graphical representation of information and data by using visual elements like charts, graphs and maps.

Augmented Reality (**AR**) **–** An interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory.

Building Information Modeling (BIM) – BIM software is used to plan, design, construct, operate and maintain buildings and diverse physical infrastructures, such as water, refuse, electricity, gas, communication utilities, roads, railways, bridges, ports and tunnels.

Computer-Aided Design (**CAD**) **–** Use of computers (or workstations) to aid in the creation, modification, analysis or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. Designs made through CAD software are helpful in protecting products and inventions when used in patent applications. CAD output is often in the form of electronic files for print, machining or other manufacturing operations. The term CADD (for computer aided design and drafting) is also used.

Cross Bore – An intrusion of an existing underground utility or underground structure by a second utility resulting in direct contact between the transactions of the utilities that compromises the integrity of either the utility or the underground structure.

Digital Camera – A camera that records digital images. Widely adopted in the damage prevention industry to assist in multiple aspects of the business.

Electromagnetic Locating – An electromagnetic locator is used for identifying utilities. They consist of two main parts, a transmitter and a receiver. The transmitter creates a current on the underground conductor that emits an EM field. The receiver detects the electromagnetic field allowing the operator to accurately locate and trace the pipes and cables above ground.

Electronic Positive Response – Communication by telephone, fax, e-mail or internet from a facility owner/operator to an excavator providing the status of an owner/operator's statutorily required response to a notice of intent to excavate.

Electronic White Lining – The process in which an excavator identifies where proposed excavation will occur by providing a shape on a GIS map; that shape is delivered electronically by the one call center to its member facility operators.

Enhanced Positive Response – See definition of positive response. "Enhanced" means that the excavator receives additional comprehensive information about the site, such as the locate request information, facility maps, photos and virtual manifests.

Geo-fence – A virtual perimeter for a real-world geographic area. A geo-fence could be dynamically generated—as in a radius around a point location—or a geo-fence can be a predefined set of boundaries (such as school zones or neighborhood boundaries). The use of a geofence is called **geofencing**, and one example of usage involves a location-aware device of a location-based service (LBS) user entering or exiting a geo-fence. This activity could trigger an alert to the device›s user as well as messaging to the geo-fence operator. This information, which could contain the location of the device, could be sent to a mobile telephone or an email account.

Geographic Information System (GIS) **–** A framework for gathering, managing and analyzing data. Rooted in the science of geography, GIS integrates many types of data. It analyzes spatial location and organizes layers of information into visualizations using maps and 3D scenes.

Global Navigation Satellite System (GNSS) – An umbrella term that encompasses all global satellite positioning systems. This includes constellations of satellites orbiting over the earth's surface and continuously transmitting signals that enable users to determine their position.

Ground Penetrating Radar (GPR) – A geophysical locating method that uses radio waves to capture images below the surface of the ground in a minimally invasive way. The huge advantage of GPR is that it allows crews to pinpoint the location of underground utilities without disturbing the ground.

Global Positioning System (**GPS) –** A satellite-based radionavigation system owned by the United States government and operated by the United States Space Force. It is one of the global navigation satellite systems (GNSS) that provides geolocation and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. Obstacles such as mountains and buildings block the relatively weak GPS signals.

High Dynamic Range Detection – High dynamic range (HDR) is a post-processing method used in imaging and photography for adding more "dynamic range" (ratio of light and dark) in a photograph to mimic what a human eye can see. A classic approach to obtain High Dynamic Range Images (HDRI) consists of combining multiple images of the same scene with varying exposures. However, if the scene is not static during the time of capture, moving objects will appear blurry and ghosted, i.e., in multiple locations. Detecting and removing ghosting artifacts is an important issue for automatic generation of HDRI of dynamic scenes. It also describes locators that can sense strong and weak signals simultaneously.

High Resolution Aerial Imaging – Aerial imagery refers to all imagery taken from an airborne craft which can include drones, balloons or airplane. Adopted by organizations looking to produce their own maps.

Hyperspectral Imaging – A technique that analyzes a wide spectrum of light instead of just assigning primary colors (red, green, blue) to each pixel. The light striking each pixel is broken down into many different spectral bands in order to provide more information on what is imaged.

Internet of Things (IoT) – A system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

Light Detection and Ranging (LIDAR) – A method for determining ranges (variable distance) by targeting an object with a laser and measuring the time for the reflected light to return to the receiver. LIDAR can also be used to make digital 3D representations of areas on the earth's surface and ocean bottom due to differences in laser return times, and by varying laser wavelengths. It has terrestrial, airborne and mobile applications.

Machine learning (ML) – The study of computer algorithms that improve automatically through experience and using data.

Positive Response – Communication with the excavator prior to excavation (typically via the one call centers) to ensure that all contacted owner/operators have located their underground facilities and have appropriately marked any potential conflicts within the areas of planned excavation.

Predictive Analytics – The use of data, statistical algorithms and machine learning techniques to identify the likelihood of future outcomes based on historical data. The goal is to go beyond knowing what has happened to provide a best assessment of what will happen in the future.

Radio-Frequency Identification (RFID) – Use of electromagnetic fields to automatically identify and track tags attached to objects. An RFID system consists of a tiny radio transponder, a radio receiver and transmitter.

Real-Time Kinematic (RTK) – Positioning that is based on at least two GPS receivers—a base receiver and one or more rover receivers. The base receiver takes measurements from satellites in view and then broadcasts them, together with its location, to the rover receiver(s). The rover receiver also collects measurements to the satellites in view and processes them with the base station data. The rover then estimates its location relative to the base.

Slot Trenching – Using pressurized air or water to cut a thin and accurate trench.

Simultaneous Localization and Mapping (SLAM) – The process of mapping an area whilst keeping track of the location of the device within that area (sometimes "synchronized" is used in place of "simultaneous").

Sonde – An instrument probe that actively transmits a radio frequency that is detectable from a locate receiver above the ground. You can insert a sonde into a non-metallic utility such as a clay sewer line and locate the sonde from above the ground multiple times to produce a locate of the entire line.

Subsurface Utility Engineering (SUE) – An engineering process for accurately identifying the quality of underground utility information needed for excavation plans and for acquiring and managing that level of information during the development of a project.

Ticket Screening – A process of filtering, sorting and automating incoming 811 tickets for the facility owner/operator or locator through the use of software rules, algorithms or AI.

Total Stations – An optical surveying instrument that uses electronics to calculate angles and distances.

Thermal Imaging – The technique of using the heat given off by an object to produce an image of it or to locate it.

Tracer Wire – Used to assist in locating non-metallic buried pipe, such as plastic. It is laid alongside the buried pipe and is a conductor of the current that generates the electromagnetic signal that electromagnetic locating techniques search for.

Unmanned Aerial Vehicle (**UAV**) (also known as a drone or uncrewed aerial vehicle) **–** An aircraft without a human pilot on board. UAVs are a component of an unmanned aircraft system (UAS), which include a UAV, a ground-based controller and a system of communications between the two.

Vacuum Excavation – A means of soil extraction through vacuum; water or air jet devices are commonly used for breaking the ground.

Appendix B: Organizations Sponsoring and/or Funding Research and Development

- American Gas Association
- American Public Works Association
- American Society of Civil Engineers, Utility Engineering and Surveying Institute
- California Geographic Information Association
- Cross Bore Safety Association
- Gas Technology Institute
- Geospatial Information and Technology Association
- Northeast Gas Association (NYSEARCH)
- Operations Technology Development
- Southern Gas Association
- Urban and Regional Information Systems Association
- Western Energy Institute
- US DOT Pipeline and Hazardous Materials Safety Administration (PHMSA)

Learn More About the Technology Committee

If you or your company are interested in learning more about the CGA Technology Committee or a specific topic, please reach out to the CGA Technology Committee for more information: https://commongroundalliance.com/Membership-Engagement/Committees/Technology-Committee

Technology Committee

Contribute Knowledge to the Technology Committee to be Shared

If you or your company are interested in contributing knowledge to be shared with the damage prevention industry and other CGA members, please reach out to the CGA Technology Committee. We are also interested in improvements to existing technologies that may make your work environment safer, faster, more efficient, less expensive, etc.

New case studies are continually sought after by the Technology Committee for review and possible inclusion in future reports, CGA's digital Technology Hub and/or as webinar topics. Use this link to submit information about damage prevention technologies: https://commongroundalliance.com/Forms/Technology-Report-Collection-Form

Technology Report Collection Form