CGA Common Ground Alliance

Technology Report 2021

Technology Advancements & Gaps in Underground Safety

Volume 4

Released, May 2021

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May 27, 2021

Dear Damage Prevention Stakeholders,

After a year in which we were all more dependent on technology than ever before, I am excited not only to publish the Common Ground Alliance's (CGA) fourth annual Technology Report, but also to invite you to read and share its important insights into the state of damage prevention technology. On the following pages, the 2021 Technology Report tracks how the industry is rapidly adopting and advancing technologies that can help us achieve meaningful reductions in damages to underground infrastructure.

Technology's ability to help us reverse the national trend of rising damages cannot be overstated: Three of the four best opportunities for improving the U.S. damage prevention system revolve around technological improvements, according to the Next Practices Initiative's recent Report to the Industry. More accurate and precise GIS mapping, implementation of electronic white-lining, and leveraging predictive analytics to account for variability in locate request demand have been identified as three technological mechanisms that can help create a more efficient and reliable damage prevention system – and all three of these opportunities for systemic improvement require stakeholders to bridge technological gaps.

Perhaps the single most important takeaway from CGA's 2021 Technology Report is the extent to which technological solutions for some of our most entrenched problems already exist, but equally ingrained barriers to implementing them remain roadblocks in our pathway to the next significant reduction in annual damages to underground facilities. I encourage you to read the section of this Report that imagines an idealized excavation project in the year 2030 (page 2) and then consider the fact that all of the technology described in that vision is already in existence.

> **"Perhaps the single most important takeaway … is the extent to which technological solutions for some of our most entrenched problems *already exist.*"**

CGA commends the forward-thinking technology providers who have dedicated research and development efforts to collaborating with damage prevention stakeholders in bringing new solutions to market. As with each iteration of CGA's Technology Report, the 2021 edition features case studies on a handful of remarkable tech applications in damage prevention and summarizes case studies from previous editions.

I would like to thank CGA's Technology Committee and its co-chairs for exhaustively cataloguing and tracking existing damage prevention technologies and industry gaps, and for their vision in producing what I believe is the most actionable CGA Technology Report to-date. On the following pages, damage prevention stakeholders will not only learn about new and emerging technological solutions, but also be challenged to engage with the barriers that are preventing existing solutions from being implemented.

In addition to reading and sharing this Report with your key stakeholders, CGA members can help strengthen our annual Technology Report by joining the Technology Committee or submitting new technologies for the Committee's consideration.

Finally, I invite all damage prevention stakeholders to attend CGA's 2021 Conference & Expo in Orlando this Oct. 12-15 to experience the latest in damage prevention technology.

Stay safe,

Sarah K. Magruder Lyle

Sarah K. Magruder Lyle
CGA President and CEO

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Introduction

With the ever-changing technology landscape in the damage prevention industry, stakeholders are forced to stay abreast of the evolving environment. Starting in 2018, the CGA Technology Committee has released an annual Technology Report 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.

Now in its fourth year, the Technology Advancements and Gaps in Underground Safety Report continues to provide CGA members with a look at technologies being used in damage prevention. We identify gaps that could be filled by new or modified[1] technologies, or that are in the process of being addressed by technology.

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.

In addition to the three Annual Technology Reports and 16 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

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 fourth annual CGA Technology Report we hope to better connect the dots between technology and the other aspects of the damage prevention industry, whether it be locating, excavating, one call center operations, etc.

[1] By "modified" technologies, we have in mind technologies that may have been initially developed in other industries or applications but could be applied to damage prevention.

Survey Responses (Stakeholder-Identified Gaps)

In March 2021, CGA conducted a survey of its membership asking: What technology gaps in damage prevention are you, your organization and/or your stakeholder group struggling with? Below is a summary of the responses:

- Recording abandoned facilities: Technology to mark and map existing abandoned utility facilities discovered during excavation so that the information will be available for all future usage, avoiding redundant excavator delays.
- Recording depth of facilities: Is there a way to indicate depth of utilities for the next person digging?
- Ticket management for excavators: Coordinating locate ticket volume is a huge task for excavators; not knowing what tickets are active or being re-called in creates a lot of noise in the 811 system.
- Unlocatable facilities: Finding more efficient ways to locate and mitigate unlocatable facilities.

In nearly every case, technological methods for closing these member-identified gaps exist, but liability concerns are roadblocks to the kind of data sharing that could make the damage prevention system more efficient.

What the Future Might Look Like: An Idealized Excavation Project in the Year 2030

Technology can help transform the damage prevention process, and this section of the Report imagines how an excavation project might unfold in the year 2030 by incorporating technological concepts from CGA Technology Report case studies as well as issues and processes brought to the forefront in the Next Practices Report and Locator White Paper, such as electronic white-lining, GIS-based mapping, enhanced positive response and better communication between excavators and locators/facility operators.

Imagine an excavation project with the following elements:

1. Excavator enters an electronic one call ticket using electronic white-lining.
2. Facility operators/locators respond by marking the site on time and providing an Enhanced Positive Response (EPR). The EPR includes a unique digital file (with a password or QR code) linked to the one call ticket number. The file contains information such as maps/coordinates, photographs, special instructions, etc.
3. The file is compatible with a set of hardware/software and can be uploaded to a screen in the excavating machine cab. The hardware/software are integrated with sensors on the bucket that warn the operator when they are within a certain distance of the buried line. The sensors and

buried lines are connected by Bluetooth, RFID, marker balls, GPS satellites, etc. It can be set to automatically shut down the machine or freeze the controls if needed (e.g., if the excavating equipment gets too close to a critical facility).

4. The software geofences the perimeter of the work site as defined by the one call ticket. It alerts the machine operator if they encroach within a certain distance of a buried facility or of the work area perimeter. It can be set to send these alerts to facility owners/locators and/or excavating company management. It can be set to generate reminders to renew a ticket if an expiration date is approaching.
5. The software is compatible with an inexpensive drone that excavating companies can buy or rent, or locators/utilities can provide. The EPR digital file can be uploaded to the drone. The drone has cameras and hovers over the work area. From a remote location, the facility operator/locator and/or excavating company management can monitor what the drone sees and communicate with the machine operator. The backhoe operator can initiate communication in the other direction with voice-activated controls.
6. If any unmarked, mismarked, or abandoned facilities are found during the project, the drone maps them via integrated GPR and/or takes photos. That information is provided back to the facility operators who can verify it and update their files as needed.

7. Ideally all affected facility operators participate in the EPR. The software overlays the information from all the participating facility operators.

Reviewing the case studies from the first three Technology Reports, plus the new ones in this year's Report, we find that many of the elements needed to make this idealized excavation project a reality already exist. On the next page is a brief summary of the cases studies, with the related element(s) following in parenthesis. Although not a numbered element of the idealized excavation project, a GIS-based mapping system would underpin the system that makes the rest of it possible, and as such is included as "(Mapping)" where applicable.

2021 Case Study Summaries

To read the 2021 case studies in full, see Appendix A.

- Gopher State One Call: White-Lining of Excavation Areas by Digital Methods
  Electronic (or virtual) white-lining is the application of a visual indicator outlining the actual excavation area to a digital base map by a notification center representative during the phone-in process or by the excavator as they enter their ticket online. The resulting map, complete with the virtual white-lining, is then shared by the notification center with all facility operators. This record can aid the locator in more easily and precisely determining the scope of the work.
  (Element 1 of 2030 Ideal Excavation Project)

- Sawback Technologies, Inc.: Lightweight, Mountable Ground Penetrating Radar
  Application of conventional GPR to locating has historically been limited by the size and weight of the units, and the need to be in contact with the ground. Sawback's system can be used from above ground level, and potentially mounted on drones. Other GPR limitations have involved the skills and time needed to interpret results. Sawback's system maps and integrates the data into a visual layer that is easily viewed via Google Maps, with the intent to make the same data accessible in point cloud format, allowing tools with the ability to visualize data in 3D format.
  (Mapping)

- Unearth Technologies, Inc.: Application of OnePlace, a Map-Based Work Management Platform, to a Cross Bore Detection Program
  OnePlace is a map-based work management platform that allows users to capture, access and share data from anywhere. It runs entirely in the cloud, which means it can be accessed on a mobile phone or tablet via native app or web browser. This case study discusses how it was applied to a cross bore detection and mitigation program, but it could theoretically be applied to tracking abandoned facilities, stub-service lines, damage and near-miss locations, and past digging activities.
  (Mapping)

- PelicanCorp: Leveraging Smart Technology to Overcome Rising Locate Volumes
  A program called "ScreenAccess" provides an automated solution for processing locate requests. The technology receives locate tickets and compares the location of the job to the location of the facility operators' network. Tickets are categorized based on the work being performed and the nature of the asset potentially at risk. Maps can be prepared and dispatched to both the facility operator and the contractor. Contractors receive an email outlining procedures and requirements for working in and around the buried facilities. This case study is written from the perspective of locators managing ticket volume, but it also has elements of an automated enhanced positive response from an excavator perspective.
  (Element 2 of 2030 Ideal Excavation Project; Mapping)

Case Study Summaries from Past Annual Technology Reports

- 2018, Gas Technology Institute (GTI) working with Pacific Gas and Electric (PG&E): Reducing Excavation Damage in the Natural Gas Industry Using Real-Time GIS and Sensors
  Using GIS and Internet of Things (IoT) features, the technology provides a means for analyzing in real-time the proximity of excavation equipment to the gas system, signaling to the operator using audible and visual alarms that a gas main is nearby.
  (Elements 3 and 4 of 2030 Ideal Excavation Project)

- 2019, Condux International and Reduct NV Advanced Technological Tools: Utilizing Inertial Navigation Technology for 3D Mapping, Locating, and Managing Underground Pipelines
  An advanced technological tool that will enable mapping of live gas pipelines and seamlessly load data to a GIS cloud database.
  (Mapping)

- 2019, Berntsen International, Inc. – InfraMarker: Seattle Sound Transit Light Rail Project Utilizes IoT Solution to Mark and Manage Underground Utilities
  Combining RFID-enabled magnetic tags, UHF (Ultra High Frequency) readers, cloud data management services, and geo-locating software, this solution marks, locates and manages underground assets. Digitally capturing and sharing project information on specific utility assets allows the information to be easily accessible to field operations and asset management personnel.
  (Mapping)

- 2020, SeeScan - GEO® Locating System: A Data-Driven Solution for Locating and Mapping Buried Utilities
  The GEO® Locating System uses advanced signal processing to gather a substantial quantity of data about the electromagnetic signals in the locate area. The system generates a comprehensive map of utilities, backed by data gathered from the locating equipment. The system includes a web-based GIS platform called SubView™ for creating and sharing utility maps based on the data gathered from the other components of the system. SubView™ processes all data and produces a complete map of utilities in the area, including each utility's estimated horizontal position and depth.
  (Element 5 of 2030 Ideal Excavation Project; Mapping)

- 2020, Leica Geosystems: Democratizing Ground Penetrating Radar Technology to Non-GPR Experts for Faster, Simpler, and Reliable Detection of Underground Utilities
  A new GPR technology called the DSX is a portable utility detection solution designed with non-skilled GPR users in mind. Users can now easily locate underground utilities and clearly visualize detected utilities via the onboard acquisition software called DXplore.
  (Element 6 of 2030 Ideal Excavation Project; Mapping)

Technology Opportunities, aka Gaps in Damage Prevention

This section lists gaps that the CGA Technology Committee has identified from various meetings within the industry. It illustrates opportunities for technology development—a wish list of technology innovations to improve damage prevention.

Locating
Locating non-metallic lines
Locating and tracking abandoned facilities
Mitigating signal bleed-over to non-target lines while using locating instruments
Ensuring that new buried assets are locatable
Dynamic/flexible due date/times for tickets with constraints for peaks
Updating GIS database of record with accurate data of as-buried during locate (maybe in GPS/Digital Mapping/GIS section)

Predictive Analytics/Risk Assessment
Providing continued analysis of root causes of damages
Predictive analytics/risk assessment to aggressively delay/"clear" low-risk tickets during volume spikes

Digital Mapping/GIS
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 the condition of the pipe
Providing better GNSS signal strength in urban canyons and under tree cover
Mixed reality to visualize underground utility lines through a mobile phone or tablet

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

Conclusion

Technology is a critical component of damage prevention and has the potential to be a primary driver in greater efficiency and improved safety outcomes across the damage prevention system. As such, damage prevention technologies must be identified, evaluated and shared so that everyone involved in protecting underground assets has an opportunity to use technology for their own regional needs. The CGA Technology Report shares the collective knowledge about these innovations with the goal of furthering discussions, improvements and better ways of applying technologies. As an almanac of underground damage prevention, the CGA Technology Committee will strive to expand upon and improve its annual report for the betterment of the industry as a whole. Education is a powerful tool for change!

Appendix A: 2021 Case Studies

Case studies on damage prevention technologies are welcomed by the Technology Committee for review and possible inclusion in future reports and/or as webinar topics. The goal of the Committee is to provide information about technologies that are in different stages of development and which have solid potential for making a positive change in damage prevention.

Four case studies are included on the following pages:

1. Gopher State One Call: White-Lining of Excavation Areas by Digital Methods

2. Sawback Technologies, Inc.: Lightweight, Mountable Ground Penetrating Radar

3. Unearth Technologies, Inc.: Application of OnePlace, a Map-Based Work Management Platform, to a Cross Bore Detection Program

4. PelicanCorp: Leveraging Smart Technology to Overcome Rising Locate Volumes

Level of Production Guide

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

Red – 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 – in full production and available for purchase

Case Study 1: White-Lining of Excavation Areas by Digital Methods

Case Study From:	Gopher State One Call and One Call Concepts, Inc.	
Contact Name(s):	Barb Cederberg	Joshua Spurgeon
Contact Email(s):	barbara.cederberg@gopherstateonecall.org	joshuas@occinc.com
Area of Technology:	Call Center, Locating, Excavation Safety and Damage Prevention	
Level of Production:	Green	

Introduction

One principle that informs the process of damage prevention is this: More detailed information shared more precisely among stakeholders will help reduce damages. Improved ticket distribution, electronic positive response and the ability for excavators to share attachments with operators through the ticketing process all illustrate this principle.

Excavators pre-marking a job site with white paint or stakes ("white-lining") has long been recognized as an important tool that can be used to define for the locator the area more precisely that must be marked. Some states have recognized the importance of white-lining by incorporating it into their damage prevention laws. The use of white-lining improves the level of detail regarding proposed work using visual indicators.

Electronic or "virtual" white-lining is the application of a visual indicator outlining the actual excavation area to a digital base map by a notification center representative during the phone-in process or by the excavator as they enter their ticket online. The virtual white line is created as part of the locate request process from information provided by the person who has the most direct knowledge of the work being done. The resulting map, complete with the virtual white-lining, is then shared by the notification center with all facility operators. This record can aid the locator in more easily and precisely determining the scope of the work.

Background

White-lining was an original CGA Best Practice. In 2017 it was updated to include "electronically."

> Best Practice 5–2 White-Lining:
>
> *When the excavation site cannot be clearly and adequately identified on the locate ticket, the excavator designates the route and/or area to be excavated using white pre-marking, either onsite or electronically (when available through the one call center), prior to or during the request for the locate ticket.*

In 2017, PHMSA issued a report titled, "A Study on Improving Damage Prevention Technology." The report resulted from PHMSA's extensive investigation into various excavation practices relating to pipeline safety. Several of the items in the report refer to white-lining:

> *"White-lining. Standardize the requirement for and improving the methodology of 'white lining' (pre-marking the proposed excavation site with white paint)."*
>
> [Reference: https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/docs/news/18351/reporttocongressonimprovingdamagepreventiontechnologyaug2017.pdf]

PHMSA also issued a report in 2017 regarding Supported Research and Development Projects and the Competitive Academic Agreement Program. The results contain information about virtual white-lining:

> *"Virtual White Lining ™ indicates exact 'excavator defined' dig area visually, on ortho-photography without the need for a site visit. The technology allows the excavator to identify for the locate technician a clear delineation of the proposed dig area."*
>
> [Reference: https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/docs/news/18346/improvingdamagepreventiontechnologyappendixaug2017.pdf]

Additionally, according to Terry L. Fordham (UtiliQuest president and CGA Next Practices Advisory Committee member, "*White-lining is one of the best communications tools available between the excavator and the locator. Accurately defining the excavation area eliminates wasted effort and over-marking. Electronic or virtual white-lining takes it to the next level and improves efficiency.*"

In 2016, the Minnesota 811 System, known as Gopher State One Call [GSOC], began using electronic white-lining tools. In 2019, GSOC began using enhanced software tools to improve the user's experience with digital white-lining by electronic methods.

While the GSOC digital white-lining tools aid in locating efficiency, Minnesota state statute requires white-lining of the excavation site in the field and precise marking instructions on the locate ticket.

Challenge

Current methods of physical white-lining (placing white paint, flags or stakes at the job site) can be problematic for larger more complex sites. Pre-marking in white in the field generally results in additional labor and material costs to be borne by the excavator. These additional costs accumulate quickly for busy excavators. Incorporating virtual white-lining into the creation of the locate request simplifies the distribution of the information to locate technicians and makes the process of advance identification more cost-effective.

The results of pre-marking in white with paint, flags or stakes are vulnerable to weather, grading and other disturbances which can destroy white markers, requiring the excavator to re-mark.

Solutions

- Electronic ticket submission tools and mapping view technologies which can be accessed remotely or on site
- Walking the site with a GPS unit and recording the data points on-site
- Employ augmented reality (AR) by using virtual overlays over live imagery on site in real-time

Each of these methods reduce cost, save labor and record the area(s) of proposed excavation. We will explore relevant digital white-lining methods via electronic ticket submission tools in the remainder of this paper.

Figure 1 – Use of Street Excavation tool along highway for pavement repair/replacement

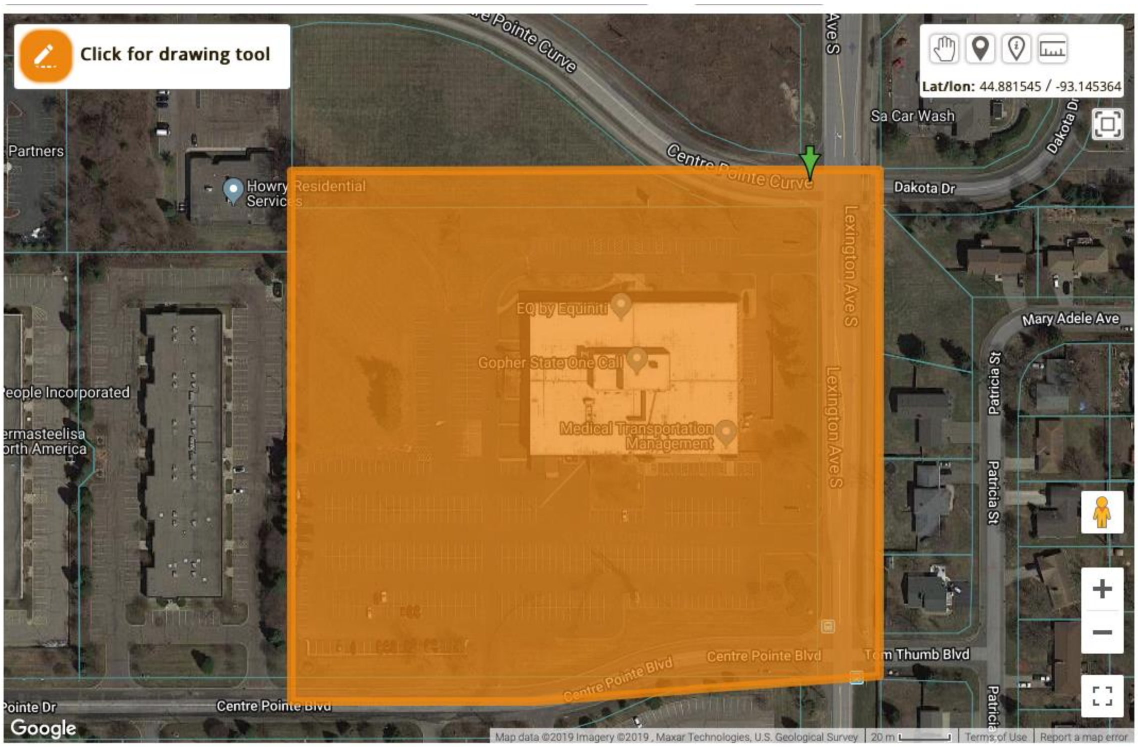

Figure 2 – Use of the Parcel tool at business parking lot for pavement replacement

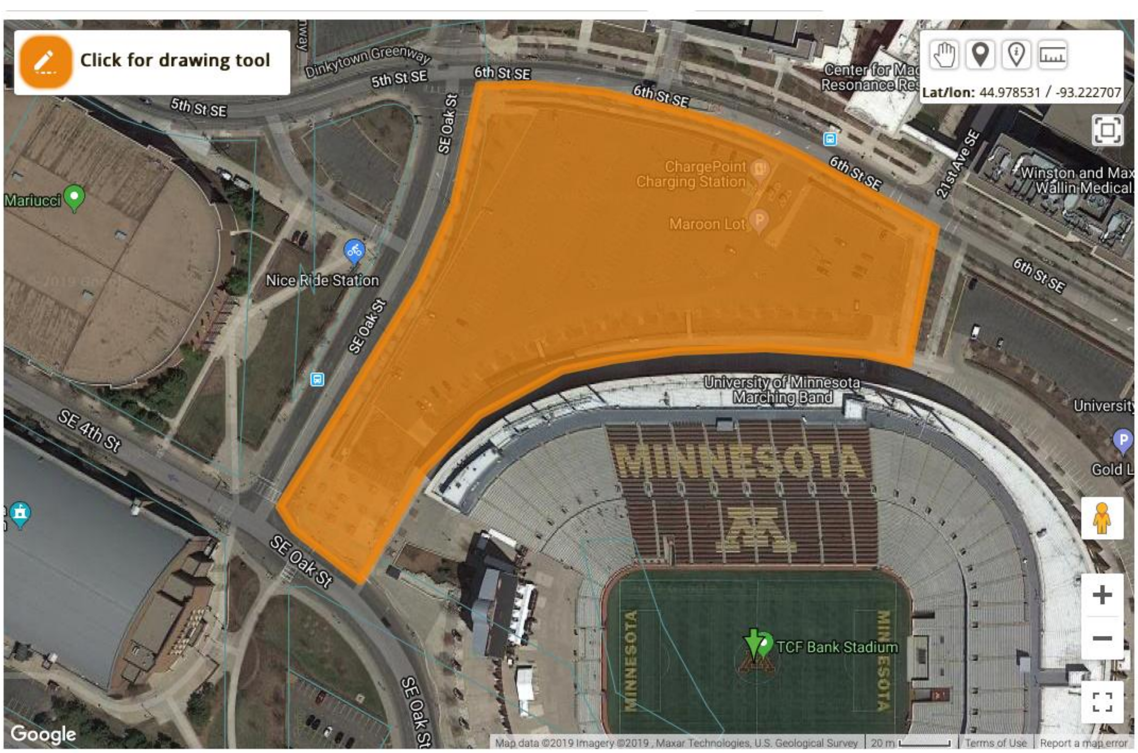

Figure 3 – Use of Polygon (Other) tool at stadium parking lot for installation of security lights

Figure 4 – Use of Route tool at quarry for fiber optic communication installation work

Operational Implementation

Performing this task electronically on the one call center map provides additional information to the locator, especially before they arrive on site.

1. Excavator outlines (or surrounds) the area(s) of excavation.
2. Record of excavation entities[2] are stored with the ticket number for later retrieval.
3. Locator/facility owner/utility company can view the map of the outlined excavation area(s) as well as how those areas relate or interfere with the facilities they own or are responsible for. This in turn helps them to determine the areas to be located and which areas are clear.

This is helpful to all parties involved as it increases accuracy, reduces time on the job, and produces a record of the white-lined excavation area. Digital white-lining is a cost-effective and affordable solution to mark the excavation area. Virtual white-lining as described here still requires precise marking instructions included in the ticket. The virtual area described may be larger than described by the precise marking instructions.

[2] Excavation Entity: A circle, route, parcel, GPS-generated polygon or free-hand polygon representing an area of excavation. The user creates a discrete excavation entity during a session as they identify the limits of an area of work. Users can create as many excavation entities as necessary during a single session.

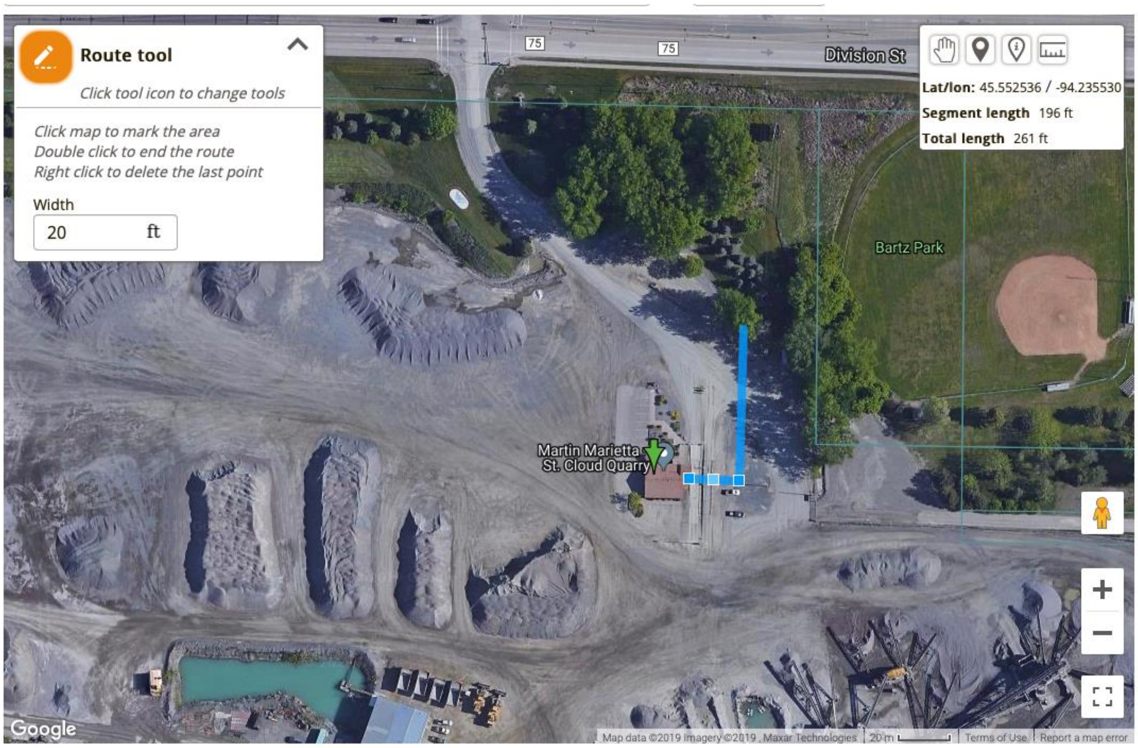

Figure 5 – Excavator selects the Route tool in the ITIC nxt interface and enters width of 20ft.

Figure 6 – Excavator begins plotting the route on the map using the mouse by placing route points

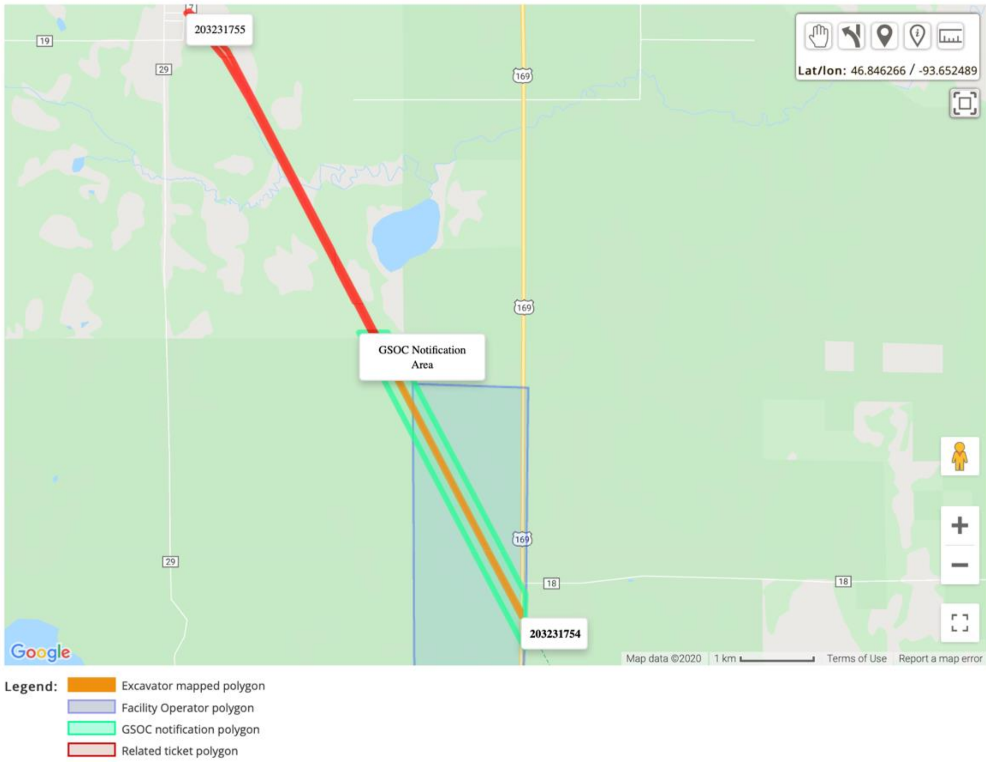

Figure 7 – Locator sees route on Locator Ticket management map view

Figure 8 – Locator sees where proposed excavation areas overlap with underground gas facilities

It is important that the excavation entities drawn by the excavators when they submit the tickets can be viewed by the locators in the field. These excavation entities encompass the very precise excavation area described in the marking instructions. In the case where the excavation entity is a route along a roadway or a radius of a specific field identifiable object, then these are useful “white marking” type identifiers.

For polygons and parcels, the excavation entity drawn by the excavator is more of an approximation of where the excavation is, as the precise area to be marked is within the drawn polygon or parcel. In all cases, it is important that the excavation area drawn by the excavator be transmitted to the facility operators and/or the contract locating companies as an “all points” polygon so that the integrity of the originally drawn excavation entity is maintained.

Locators have provided feedback that when the integrity of the excavation entity is maintained, it saves time in determining where to locate per the precise marking instructions on the locate request. In Minnesota, several major ticket management companies have modified their processes to ensure the integrity of the excavator drawn polygon. The integrity of the route narrowed down the area where the precise marking instructions were telling them to mark rather than the larger area that the ticket management systems would create when they did not use the “all points” process.

Customer Feedback

Jason Ponsiano, Vannguard Utility Partners:
“It helps the locators if the excavation box on the map is drawn as tight as possible to match the marking instructions.”

Adam McAlpine, USIC Minnesota:
“Any additional information relayed to locate companies is helpful. This is helpful. Would like it to be more precise. White-lining is still the best.”

Conclusion

As noted in the opening, more detailed information shared more precisely among stakeholders will help reduce damages. Virtual white-lining as we have described opens the door for improved record keeping, greater virtualization and enhanced communication. Virtual white-lining results in increased efficiency for both the locator and the excavator, while also helping to reduce damages and lower costs.

Continued availability of better and less expensive technologies means that electronic white-lining will continue to become more efficient and cost effective. The constant imperative to reduce damages means that advanced technologies will continue to be applied to improve safety, revise excavation and locating practices, and increase proficiency in the art and science of the 811 industry for all stakeholders.

Use of ‘white markings’ is currently required by MN state law. Maybe states that require physical white markings will begin to adapt digital white-lining as an acceptable form of marking the area of proposed excavation.

[Reference: https://www.revisor.mn.gov/statutes/cite/216D.05]

[Reference: https://dps.mn.gov/divisions/ops/Pages/gopher-state-one-call.aspx]

[Reference: http://www.gopherstateonecall.org/news-events/672-how-to-submit-precise-marking-instructions-on-your-ticket-and-mark-the-excavation-area-in-white]

The Future…

Figure 9

Case Study 2: Lightweight, Mountable Ground Penetrating Radar

Company's Name: Sawback Technologies Inc.

Contact Name: Neil Keown

Contact Email: neil@sawbacktech.ca

Area of Technology: Locating Device

Level of Production: Yellow

Ground penetrating radar (GPR) technology has been around since the early 20th century, and in recent decades has been a useful tool to identify objects of interest located beneath the soil. The technology, as reflected in modern units, works best when the device is in contact with the ground. However, this creates a few problems for users. Using conventional GPR units to map large areas in a cost-effective and timely manner is unfeasible, and terrain that is rough or inaccessible by personnel precludes its use for locating buried utilities prior to excavation. Furthermore, there may be environmental implications in protected areas which can be undesirable for sensitive projects that seek to minimize unintended damage. Lastly, the data collected often needs skilled personnel to interpret, and a frequent complaint from end users is the length of time needed to provide actionable results, which creates schedule delays and frustrations.

The Sawback solution addresses the above limitations by allowing the sensor to be used without actually having to be in contact with the ground. Our hardware can be mounted on either earth-moving equipment or on a Remotely Piloted Aircraft System (e.g., a drone), allowing clients to check for buried infrastructure in real-time while they are excavating, and to map buried utilities on areas that posed difficulties due to rough terrain.

Test Case #1

Working with a local municipality, we tested our prototype solution that could be mounted on a drone to assist in identifying and mapping a buried pipeline in a reclaimed landfill. Due to the soil conditions and weight of conventional GPR units, the terrain would have precluded the use of conventional GPR technology.

The 36” gas pipeline in question was at a variable depth of 17-45” below grade, with the soil conditions being dry and frozen, and light snow in the testing area.

Horizontal location information provided by the municipality was used as a baseline to compare against data collected using the prototype. The hardware was suspended via a wooden frame, to simulate drone data collection (see Figure 10) at a height of 6’6” above the ground surface. Numerous data points were collected and tagged with location (GPS) coordinates from a survey grade-base station. The Sawback solution has been designed with onboard Global Navigation Satellite System (GNSS) capability, with the option to connect to a survey-grade base station for high accuracy positioning.

Figure 10 – Prototype hardware to simulate drone sensor data collection

After the data collection was completed, post-processing identified the depth of cover for the pipeline with an accuracy of +/- 4”, which is expected to improve in the final commercial product and ongoing processing improvements. The data was then mapped and integrated into a visual data layer that is easily viewed via Google Maps (see Figure 11), with the intent to make the same data accessible in point cloud format, allowing tools with the ability to visualize data in 3D format (using AutoCAD or equivalent software).

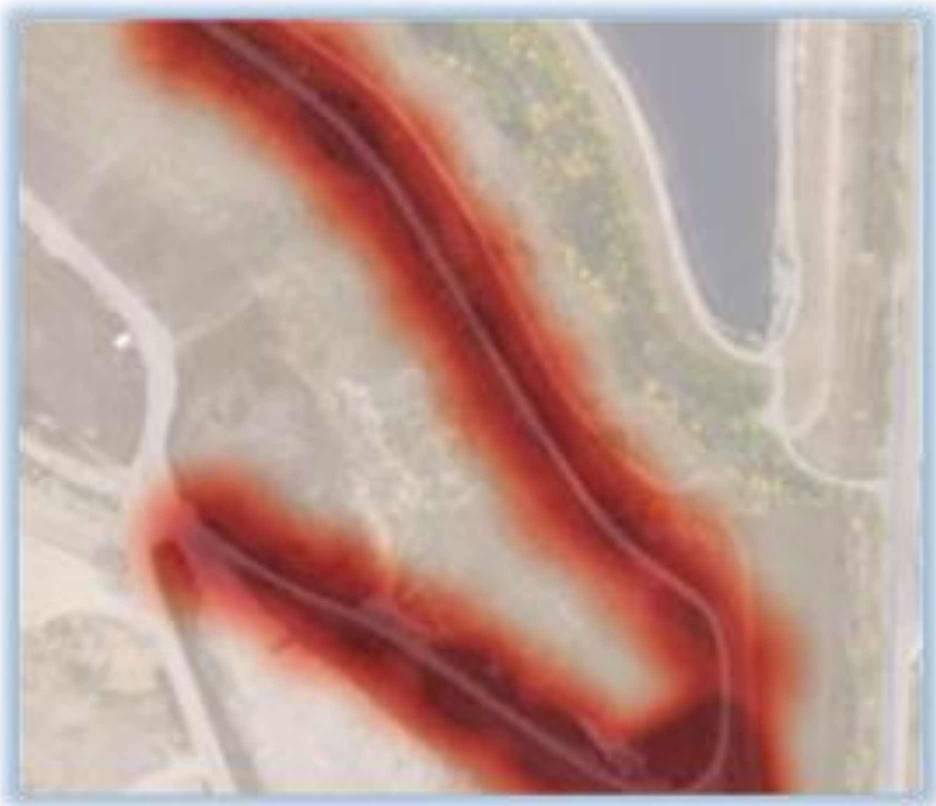

Figure 11 – Pipeline map using data from prototype hardware

The successful test validated that deploying the Sawback solution via drone will provide tangible benefits to those who require accurate horizontal and vertical geo-data for buried utilities mapping and identification.

Test Case #2

A local contractor expressed the need to have real-time information as to what was beneath the ground, as they were involved in several near misses of buried utilities marked by conventional (e.g., non- GPR) methods. Their intent was to provide an additional layer of safety during excavation operations, in the event that utilities were missed or not identified accurately in the conventional locating process.

The primary interest for the contractor would be an indicator in the operator cab that would signify if there was a hazardous object below the bucket, with a potential interest of having a real-time display capable of showing where, and how deep, the object was.

Using their excavation equipment (see Figure 12), we installed our prototype solution, identical to what was used in Test Case #1, and began testing. The contractor had previously located, using their own equipment, the position and depth of cover of a buried electrical cable (3/4”diameter), at a variable depth of 60-78” in their equipment yard. The soil conditions consisted of crushed gravel as the primary soil layer, with some water puddles throughout the testing area.

Figure 12 – Sensor prototype on excavator test

The excavation equipment carrying the solution drove slowly over the testing area and cable with measurements taken every second, and each measurement tagged with coordinates collected from a survey base station. Tagging the measurements allows for mapping any buried objects afterwards, akin to Test Case #1. The equipment was tested at various elevations (starting at 78”, then lowering at 12” intervals until 6” from the ground) and was also tested at angles ranging between 45-90 degrees (perpendicular to the ground).

In all cases, the cable was identified accurately (sub-centimeter accuracy), and with the depth of cover at +/- 4”, although high accuracy in this circumstance is not necessarily required (unlike Test Case #1).

Figure 13 depicts the raw data received from the prototype sensor, after initial processing. Additional processing will provide a clearer image, allowing for a real-time display for the equipment operator to monitor during excavation activities.

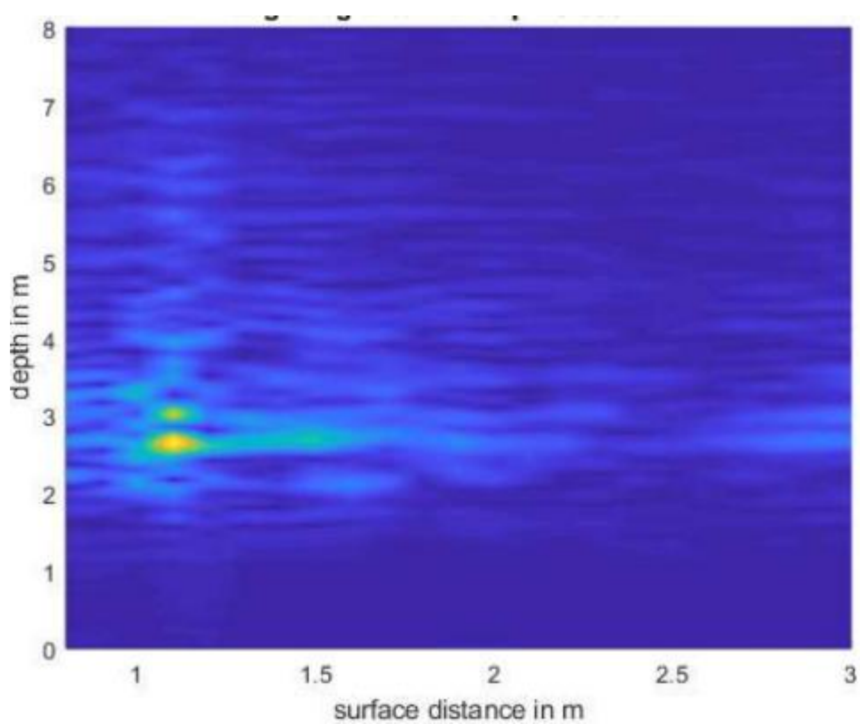

Figure 13 – Buried electrical cable found using prototype sensor on excavator

Conclusion

Given the above test cases, Sawback has moved forward with progressing the solution from prototype to the commercial stage, with the attaching of the hardware to either drone, or excavation equipment, as it can be installed with minimal changes on either platform.

Case Study 3: Applying OnePlace, a Map-Based Work Management Platform, to Legacy Cross Bore Detection and Mitigation

Company's Name: Unearth Technologies, Inc.

Contact Name: Morgan Sullivan

Contact Email: morgan@unearthlabs.com

Area of Technology: Geospatial Work Management

Level of Production: Green

Introduction

Cross bore detection and mitigation programs face a multitude of challenges:

- Large quantities of data coming from both digital and analog sources
- Inherent difficulty in creating a unified system of record
- The sheer size and scope of cross bore inspection projects

As a result of these challenges, cross bore detection and mitigation programs are often plagued by duplicative documentation processes, slow turn-around times on inspections, and uneven, hard-to-find historical records.

The most troubling outcome is that the longer a latent cross bore goes unaddressed, the greater the risk for everyone. Each unaddressed cross bore carries close to $30 million in potential financial risk – a figure that doesn't speak to the unquantifiable cost of potential lost lives.

Considering all these factors, it is clear that the current system is unsustainable. Mitigating cross bore risk efficiently requires a different set of tools.

Efficiency improvements can be made in two ways:

1. Increasing end-to-end inspection and clearing speed
2. Decreasing the cost of each inspection

OnePlace, a map-based work management software, was developed in direct response to the challenges discussed above. Our client – a major transmission and distribution company with over 4 million customer accounts in natural gas – used OnePlace to increase efficiency within their legacy cross bore program in the following ways:

- Labor needed to complete an inspection decreased by 60%
- QA/QC review decreased from six weeks to six hours

- Number of laterals cleared per day increased by 20%

All these results were achieved within the first year of implementing OnePlace. As platform usage becomes more rote, it is expected that efficiency gains will continue throughout the next few years.

Additionally, OnePlace also addresses eight of the nine technology gaps in GPS, digital mapping and GIS technology as identified in CGA's 2020 Technology Report.

What is OnePlace?

OnePlace is a map-based work management platform that allows users to capture, access and share data from anywhere. It is similar to GIS in that users can create maps and organize data by location.

That said, it differs from GIS in three key ways:

1. Cloud-based architecture
   OnePlace runs entirely in the cloud. This means it can be accessed on a mobile phone or tablet via native app or web browser – essentially, any device connected to the internet. This also means data can move between the field and office in real-time.
2. Data agnostic
   OnePlace accepts any file type including Shapefiles, GeoJSON, GeoTIFF and CSV. This means it can be used in tandem with traditional GIS platforms, enterprise asset management (EAM) systems and professional-grade survey devices.
3. Modern user interface
   Unlike many legacy platforms, OnePlace benefits from modern software design. It was built with users in mind and intended to be as simple as possible.

When implemented within a cross bore program, these three components combine to improve procedural efficiency from start to finish.

Using OnePlace to make cross bore detection and mitigation more efficient

Most cross bore programs have various bottlenecks throughout the inspection and mitigation process. In the case of our customer, two of the most significant were parcel mapping and QA/QC review.

Parcel mapping was slowed by the format of the available data: paper and PDFs. Before rolling out OnePlace, each subcontractor used different manual methods to document their inspections. Most methods involved creating hand-drawn maps, scanning them into PDFs and then burning files onto stacks of DVDs. With this process, creating a map in the field for a small parcel took over three days.

Meanwhile, QA/QC review faced its own challenges. First, all inspection data had to be checked for completion and validity, and then manually transferred to our client – usually in the form of a DVD. With so many different data formats (paper maps, photos, inspection videos, etc.), this review process was extraordinarily time consuming.

That was just on the contractor side. Once receiving the completed deliverable, our client then had to recreate that same data within their own system of record. All in all, the review process could take up to six weeks.

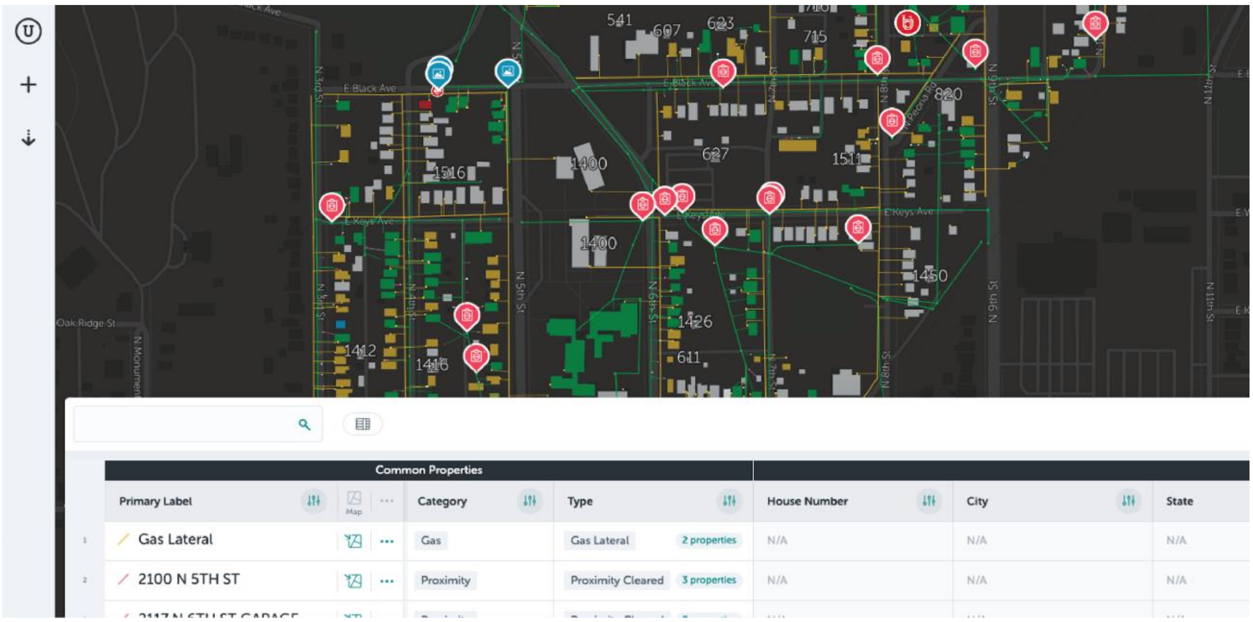

Figure 14 – Parcels, assets and photos added to digital map of the worksite

Using OnePlace, this complex process was streamlined into a few simple steps:

1. Our client uploads and assigns parcels to contractors.
2. Contractor project managers assign areas or specific parcels to a field team.
3. Field teams upload inspection data (photos, videos, comments, etc.) directly into the system while still on-site.
4. Uploaded data becomes immediately available for review.
5. Once reviewed, the process is complete.

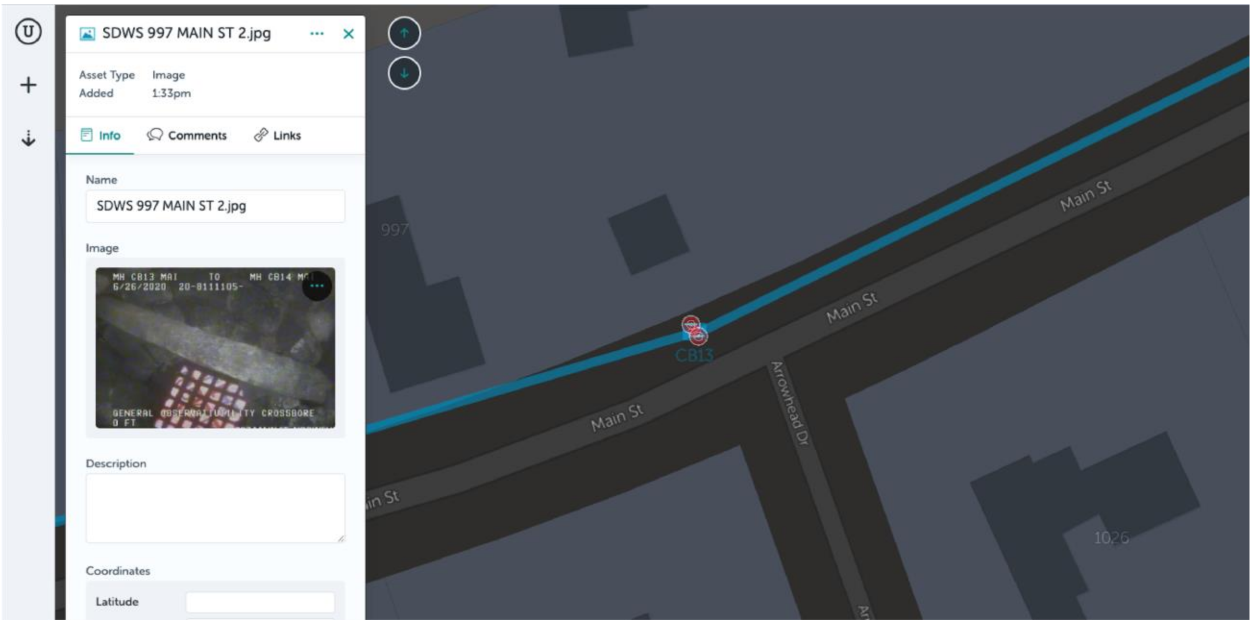

Figure 15 – Adding an inspection video and associating it to the mainline where it was taken

All of these steps occurred within OnePlace, eliminating the need to transfer data between different formats and systems.

This new approach replaces the patchwork quilt of paper maps, printed PDFs and handwritten notes. It also eliminates long wait times, boxes of DVDs and hard drives, as well as time consuming manual transcription.

Implementation

Implementing OnePlace within our client's legacy cross bore program took approximately six months, but a more standard timeline is three months. The size and complexity of that specific project – the worksite covered close to 50 square miles – necessitated a longer roll-out period. The first step in the implementation process was integrating a large dataset covering 10 years of historical work, as well as records on every single lateral requiring inspection. This portion took about three months and accounts for the discrepancy between a usual implementation timeline and this particular project.

Once this data was cleaned and uploaded, the Unearth data and customer success teams were able to create a project site. From there, the process continued along the standard implementation path. The Unearth customer success team worked closely with our client and their inspection contractors to create a custom digital toolkit. The primary focus here was to ensure the toolkit aligned with existing project terminology and could support existing processes.

The next step was user training sessions. These sessions focused on different tasks for both our client and their contractors. For our client, training revolved around reporting and administrative functions. For contractors, the focus was on effective use of field tools.

After training, the platform was in use within days, both within our client's office and the field. OnePlace was built to be very simple: once everything is set up on the back end, actual usage is quick to implement – generally a few days.

Addressing technology gaps

Our client's experience with OnePlace offers a focused look at how map-based work management software can improve efficiency. However, it is also valuable to consider this type of software from a broader perspective.

In its 2020 Technology Report, CGA identified nine gaps in the category of GPS, digital mapping, and GIS technology:

1. Mapping near misses—collecting and enabling use of this data
2. Mapping damage locations
3. Providing increased locational data sharing
4. Providing centralized database of mapped abandoned facilities
5. Creating "open" GIS systems that provide better data sharing
6. Mapping assets through mainline inspections and associating location with video
7. Providing better GPS signal strength in urban canyons and under tree cover[3]
8. Providing software analysis for quality feedback about GPS coordinate collection
9. Developing standards for GPS data quality

These gaps fall into four broad categories:

- Issues with data capture and sharing
- Inability to create accessible centralized databases
- Difficulty creating maps with large quantities of geographically dispersed information
- Issues with data quality

Our client's experience using OnePlace reflects how the platform effectively addresses three of the four categories: data capture and sharing, centralized databases and creating maps with large quantities of geographically dispersed information.

At this point, it is difficult to accurately assess how OnePlace has affected data quality within our client's operations. OnePlace enables the creation of a centralized data repository – a vital component of both data analysis and data standard creation. With that in mind, the working assumption is that with enough time the platform will also help our client to address data quality issues. The potential for positive change is there, but time will tell the full extent.

[3] Technology gap not addressed by map-based project management.

Case Study 4: Leveraging Smart Technology to Overcome Rising Locate Volumes: Test Case Studies of Regional Water Authority and GNHWPCA

Company's Name: PelicanCorp

Contact Name: Sam Handziak

Contact Email: Sam.Handziak@pelicancorp.com

Area of Technology: Ticket Automation/Communication

Level of Production: Green

In its 2021 Next Practices Initiative Report to the Industry, CGA raised a warning regarding the sustainability and adequacy of the current U.S. damage prevention model. The report noted that "stresses on the system have caused inefficiencies, resulting in a process that is not protecting critical infrastructure as well as it could or should." Primary stressors to the system were identified as high variability and annual increase to locate volumes. To prepare for and overcome these challenges, two insights were offered. The first being that the industry as a whole must reimagine the relationship between stakeholders, identify synergies and address gaps in communication. Secondly, automation and technology are the best and most effective method to meet these challenges.

This case study will present test cases that illustrate how stakeholders can leverage existing technology to overcome the volume and variability problem all while continuing to protect their assets and the people who work around them. Additionally, this case study will examine the cost savings and efficiency gains that can be realized through the deployment of smart technology.

Test Case: Greater New Haven Water Pollution Control Authority

Greater New Haven Water Pollution Control authority (GNHWPCA) is a Regional Sewer Authority with over 555 miles of sewer mains, 30 pump stations and the second largest wastewater treatment plant in Connecticut. Rick Hurlburt, superintendent at GNHWPCA explains that "the existing CBYD response process required three full-time staff handling tickets and scheduling field visits on anywhere from 30-80 tickets per day." For each of these tickets, work orders were created in the GNHWPCA Works Management system which would then keep track of time and material costs for each field visit. The time spent manually entering these details was resource-heavy and in many cases resulted in unnecessary field visits and inspections. "Determining which tickets actually required a response and in-turn a locate was time consuming and costly," according to Rick.

To solve the inefficiencies in their current system, GNHWPCA deployed a technology that is new to North America called ScreenAccess. ScreenAccess provided GNHWPCA an automated solution for processing locate requests. "We wanted to provide the contractor with greater awareness of critical infrastructure. Excavators didn't necessarily understand what was below the ground other than the markings on the surface," said Rick. This is achieved by providing locates when required, as well as a map. This provides a safer work environment and reduces the risk of damage to secondary or customer services. ScreenAccess has also ensured that the process still adheres to Connecticut state regulations for the CBYD service. The software runs and operates in a scalable, high-availability, cloud-managed server infrastructure with all support and service provided. The technology receives locate requests and compares the location of the job to the location of the GNHWPCA Sewer network. Tickets are categorized based on the work being performed and the nature of the asset potentially at risk. In addition to the assessment, maps are prepared and dispatched to both the GNHWPCA teams and the contractor. Contractors receive an email outlining procedures and requirements for working in and around GNHWPCA sewer networks. "The detail on the map includes the location of the sewer facilities and also, where available, the laterals and detail of any physical attributes like depth and diameter. This accuracy and detail in responses provides un-paralleled levels of information not seen in the industry," says Rick.

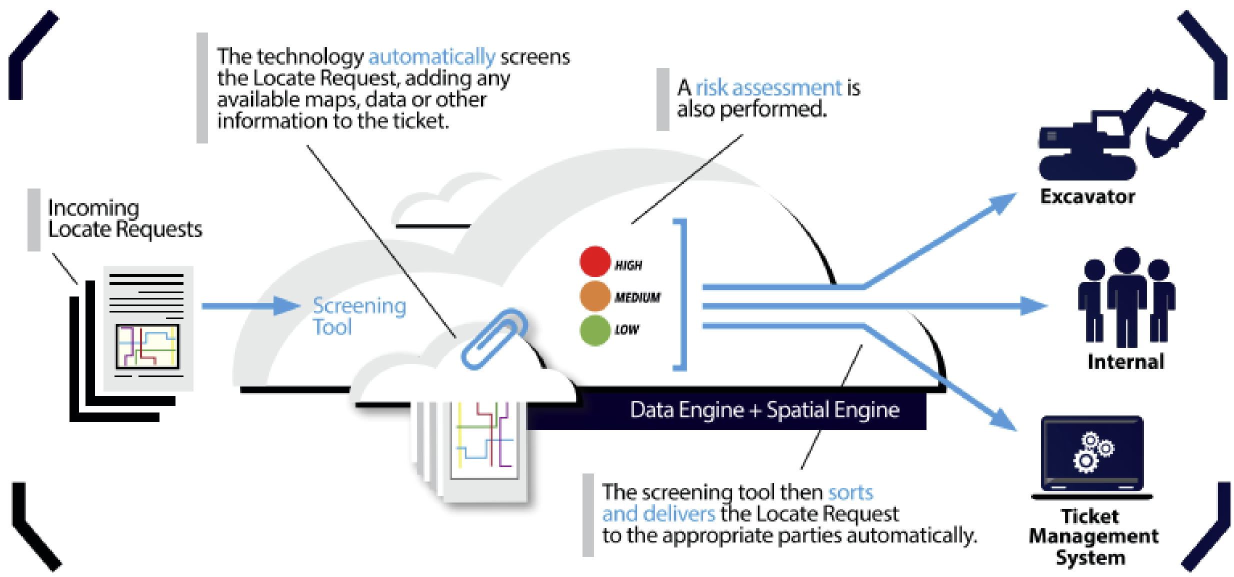

Figure 16

Immediate Outcomes for GNHWPCA:

- GNHWPCA was able to automatically screen out **75%** of their annual CBYD locate requests.
- GNHWPCA reduced their annual operating costs by **$553,095** per year.
- GNHWPCA was able to reduce the total time spent by its staff managing locate requests by **19%.**
- GNHWPCA was able to free up **two employees** who had previously been solely focused on locate management to perform other vital tasks.

Damage Reduction for GNHWPCA

After deploying ScreenAccess, GNHWPCA noted a reduction in damages to their infrastructure. Rick attributes this result to ScreenAccess' ability to automatically provided excavators detailed information and maps regarding the buried facility in the dig site. This additional information augmented the marks on the ground, allowing the excavators to dig with a greater degree of accuracy. The excavators also had the added benefit of referring to the map throughout the excavation as the marks were removed.

Test Case: Regional Water Authority

Regional Water Authority (RWA) of New Haven, Conn., implemented ScreenAccess to manage and automate their ticket screening process while providing a positive response solution. ScreenAccess connects in real time with RWA's GIS for its water distribution assets and categorizes tickets based on work performed and the asset at risk of being disturbed.

LocateAccess[4] then provides the locate management and works management for tickets handled in the field and helps RWA to easily collaborate with locators to immediately mark out critical assets while also reducing bottlenecks, automatically responding to lower risk requests that may not require a mark out. This has already significantly reduced the number of tickets required to be located and provides the added benefit of immediately identifying tickets which may impact critical infrastructure, greatly reducing workload pressures while protecting assets and public safety.

Pat Moran, operations supervisor for RWA added, "As a direct result of implementing both ScreenAccess and LocateAccess prior to the dig season, the gains in efficiency have been noticeable and significant. We are not only reducing the amount of unnecessary work from our field team by nearly 10%, but we are collecting more useful and meaningful data about the work we are completing with the addition of photos and mapping. Prior to this our ticket volumes were growing every year and our field crews were struggling with the backlog of work. This provides us with immediate and long-term operational savings, which we are very pleased with."

Immediate Outcomes for RWA:

- RWAwas able to automatically screen out **10%** of their annual locate requests.
- RWA reduced their annual operating costs by **$263,900** per year.
- RWA was able to reduce the time spent by its staff managing locate requests by **40%**.
- RWA was able to eliminate a daily backlog of over **400** locate requests, dramatically reducing both late responses and the risk of associated fines.

Conclusion

The added benefit of this technology is the communication to the excavator that assets are underground. Each year the CGA DIRT Reports indicate that about 10% of damages are caused by the excavator digging prior to the valid start dates/time of their locate request. This technology tells the excavator in minutes, not days, that assets are indeed present and to not dig without the marks.

Warning Notice Example

This notice is automatically created and delivered to an excavator whose locate request has the potential of impacting GNHWPCA's critical assets. The notice is intended to notify the excavator of the risk to GNHWPCA's assets and inform them that they must wait for the site to be marked.

[4] LocateAccess is a ticket management solution from PelicanCorp that allows incoming locate requests to be assigned to the field. Technicians can use LocateAccess to view the request, route their day and close out the locate request.

GNHWPCA
Protecting the Environment

Greater New Haven Water Pollution Control Authority
260 East Street, New Haven, CT 06511 203.466.5280 p 203 772.2027 f www.gnhwpca.com

Call Before You Dig (CBYD) Request No. 20153102163

Request Date: 07/29/2015
Town: ct.new haven
Address: long wharf dr

811
Know what's below. Call before you dig.

Dear jim knell,

Thank you for contacting Call Before You Dig (CBYD) prior to engaging in work or activities that may affect the sanitary sewer infrastructure of the Greater New Haven WPCA (GNHWPCA.)

STOP **Critical GNHWPCA sewer force mains or pressure sewer assets have been identified within your marked search area. GNHWPCA personnel will visit the site to mark the location of our sewer infrastructure and to provide additional information. The enclosed map shows the approximate location of our sewer infrastructure in the area of your project.**

Disclaimer
The information and plans provided have been generated by an automated system based on the area highlighted in your CBYD request. It is your responsibility to ensure that the excavation site is properly defined when submitting your CBYD request and it is your responsibility to ***field verify*** the location of all GNHWPCA sewer infrastructure prior to the start of work. If the information does not match the excavation site or you have received this message in error please resubmit your request or contact CBYD.

This information is given for your private use only. GNHWPCA sewer mapping data is for planning purposes only. Although compiled from record plans, there is no guarantee that this data is free from errors or omissions.

For further enquiries or assistance with interpretation of plans and search content, or to report any obvious errors with the data provided, please contact our GNHWPCA support team via email at diglist@gnhwpca.com.

Thank you for contacting CBYD service.

Best Regards,

Call Before You Dig Support Team
GNHWPCA

Please note: Any damage to GNHWPCA sewer infrastructure shall be reported immediately to our emergency number (24 hours, 7 days) at 203-466-5260.

Neither Greater New Haven Water Pollution Control Authority (GNHWPCA) or PelicanCorp makes representation or warranty as to the accuracy or completeness, or fitness for purpose of the information or data set out in this document. This asset plan is not advice. Before taking action, you need to make your own independent assessment, including whether to obtain specific professional advice. Use of such information is subject to and constitutes acceptance of these terms.

GNHWPCA CBYD Force Main Letter v1.3.docx (07/22/2015)

Figure 17

Appendix B: Glossary of Terms and Definitions

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.

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.

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 c*omputer aided design and drafting*) is also used.

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.

Geofence – 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.

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 by the use of data.

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 providing 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) – Is 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.

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.

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.

Appendix C: Summary of Current Industry Technologies

The 2018 through 2020 annual Technology Reports included a section providing a basic categorization and identification of damage prevention technologies currently in use. Going forward, this list will be maintained on the CGA website. This will serve to reduce the length of this report, provide easier access for CGA members, and allow for updates independent of the annual Technology Report releases.

The list can be accessed at https://commongroundalliance.com/technology-resources

Note: For questions about a current technology in use or to suggest additions to the catalog, please contact the Technology Committee via our web form or Contact Us page:

- *Contact Us: https://commongroundalliance.com/Contact-Us*
- *Web form: https://commongroundalliance.com/Forms/Technology-Form*

Appendix D: 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 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, then please reach out to the CGA Technology Committee for more information. *https://commongroundalliance.com/Membership-Engagement/Committees/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, then 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 and/or as webinar topics. Use this link to submit information about damage prevention technologies: https://commongroundalliance.com/Forms/Technology-Form.