2022 MALSCE Convention

Workforce Development and Attracting the Next Generation of Surveyors

DoubleTree by Hilton Leominster

99 Erdman Way, Leominster, MA 01453

Friday and Saturday, March 18 & 19, 2022

7:00 AM - 10:00 PM Friday
7:00 AM - 1:45 PM Saturday

Sponsored by 2021-2022 MALSCE Sustaining Members:

Airworks Solutions, Allen & Major Associates, Inc., Beals and Thomas, Inc., Bluesky Geospatial Limited, Brennan Consulting, Inc., BSC Group, Inc., Carlson Software, CHA, Coastal Engineering Co., Inc., DGT Associates, Donovan Hatem LLP, Eastern Topographics, Feldman Geospatial, Hancock Associates, Maine Technical Source, Moran Surveying, Inc., Nitsch Engineering, Samiotes Consultants Inc., Spiller's, Topcon Solutions Store, VHB, Inc.

Welcoming Letter

Workforce Development and Attracting the Next Generation of Surveyors

Welcome to the 2022 MALSCE Convention! The theme of this year's convention is *Workforce Development and Attracting the Next Generation of Surveyors*. The past two years have been very challenging for us professionals and technicians. The COVID-19 virus has altered the way we operate with many employees choosing to work from home. Of course, those who work outside in the field haven't been allowed that luxury. Compounding the COVID situation is the so-called Silver Tsunami. Many of us land surveyors, and the population as a whole, have graying hair. By my estimate, over half of the current registered PLSs will be retired in the next ten years or so. These demographics are clearly working counter to the stability of our profession. Finding capable workers is one of our biggest challenges.

The Central MA Chapter and the Convention Planning Committee has worked hard to put together relevant sessions in the professional track to address this key issue facing all employers. In the technical track we have sessions on improving surveying measurements, instrumentation, and structural monitoring. We trust that you'll find the sessions timely and informative.

As always, we'll be joined by over a dozen exhibitors; please make an effort to visit with them. Once again, we'll be running our plan and field notes contests and we'll be holding the Auction to benefit the MALSCE Education Trust on Friday evening which is always a lively event. This year, recent retiree Dave Humphrey will be our auctioneer. Bid early and often!

In closing I want to thank you for participating in the convention and for your continued volunteer efforts. I hope you find the sessions fruitful and fulfilling.

Best regards,

Kenneth T. Strom, PLS
Central Massachusetts Chapter President

2022 MALSCE Convention

Schedule of Events

Friday, March 18, 2022

7:00 AM - 4:30 PM
Registration Desk Open
Concourse

7:00 AM - 9:00 AM
Continental Breakfast
Beethoven/Brahms/Mozart

8:00 AM - 4:30 PM
Exhibit Hall Open
Concourse

8:00 AM - 3:30 PM
Online Plan and Field Note Contest
Beethoven/Brahms

7:50 AM - 8:00 AM
Opening Remarks
Kenneth T. Strom, PLS, Director of Surveying, WDA Design Group, MALSCE Central Massachusetts Chapter President
Strauss/Schubert

8:00 AM - 8:30 AM
Session 1: Exhibitor Quick-Fire Session
Moderator: Kenneth T. Strom, PLS, Director of Surveying, WDA Design Group, MALSCE Convention Planning Committee Cochair
Strauss/Schubert

8:00 AM - 9:00 AM
Breakout Session: Young Surveyors Network Meeting
Presiding: Charles G. Dexter, Survey Technician, Field Chief, Feldman Geospatial, MALSCE Young Surveyors Network Chair
Irving Berlin

8:00 AM - 9:00 AM
Breakout Session: North East Surveying Societies Meeting
Moderator: J. Dan Bremser, PLS, Senior Project Manager, Hancock Associates, MALSCE President
Cole Porter

8:30 AM - 9:00 AM
Break
Concourse/Beethoven/Brahms/Mozart

9:00 AM - 11:00 AM
Session 2A: Workforce Development
A. Richard Vannozzi, MS, PLS, Assistant Professor, Surveying Engineering Technology, University of Maine
Strauss/Schubert

9:00 AM - 11:00 AM
Session 2B: 50 Ways to Improve Your Surveying Measurements
Sponsored by Beals and Thomas, Inc.
Joseph V.R. Paiva, PhD, Principal and CEO, GeoLearn LLC
Junior Ballroom

11:00 AM - 11:15 AM
Break
Concourse/Beethoven/Brahms/Mozart

11:15 AM - 12:30 PM
Session 3: Reinvigorating our Profession – Perspective from the Next Generation Surveyors
Sponsored by the MALSCE Proprietors' Council
Moderator: Michael A. Feldman, President, Feldman Geospatial, MALSCE Proprietors' Council Chair
Panelists: Charles G. Dexter, Survey Technician, Field Chief, Feldman Geospatial, Shaine R. Bonin, Project Manager/Survey Technician, BSC Group, Inc., Sterling Hooke, PLS, Project Manager, Encompass Energy Services
Strauss/Schubert

12:30 PM - 1:45 PM
Lunch, MALSCE Annual Meeting and Awards Presentations: NSPS National Surveying Advocacy, and the Future of Surveying
Presiding: J. Dan Bremser, PLS, Senior Project Manager, Hancock Associates, MALSCE President
Featuring: Timothy W. Burch, PLS, Executive Director, NSPS
Beethoven/Brahms/Mozart

1:45 PM - 2:15 PM
Session 4A: Surveying Career Slide Deck for Student Outreach
David Prince, PLS, Vice President Survey Services, WSP
Strauss/Schubert

1:45 PM - 3:45 PM
Session 4B: 50 Ways to Improve Your Surveying Measurements (A Continuation of Session 2B)
Sponsored by Beals and Thomas, Inc.
Junior Ballroom

2:15 PM - 2:30 PM
Break (A Track Sessions)
Concourse/Beethoven/Brahms/Mozart

2:30 PM - 4:00 PM
Session 5A: MassDOT New Engineering Directive E-21-005, Subsurface Utility Engineering (SUE): Its Impact on Mass-based Engineers, Surveyors, and the Future of the Industry
Michael Twohig, Director of Subsurface Utility Mapping, DGT Associates
Strauss/Schubert

3:45 PM - 4:00 PM
Break (B Track Sessions)
Concourse/Beethoven/Brahms/Mozart

4:00 PM - 6:00 PM
Session 5B: Things About Instrumentation You May Have Forgotten or Never Learned
Sponsored by Beals and Thomas, Inc.
Joseph V.R. Paiva, PhD, Principal and CEO, GeoLearn LLC
Junior Ballroom

4:00 PM - 4:15 PM
Break (A Track Sessions)
Concourse/Beethoven/Brahms/Mozart

4:15 PM - 6:00 PM
Session 6A: Structural Monitoring – Tracking Movement in a Fast-Paced World
William T. Derry, Prof. LS, Technical Sales Engineer- Solutions, Monitoring, Leica Geosystems, Inc.
Strauss/Schubert

6:00 PM - 7:00 PM
MALSCE Education Trust Benefit Auction/Reception
Concourse

7:00 PM - 7:30 PM
Break

7:30 PM - 8:30 PM
Dinner
Beethoven/Brahms/Mozart

8:30 PM - 10:00 PM
Beer Tasting
Beethoven/Brahms/Mozart

Exhibitors

AirWorks Solutions
226 Causeway Street #102, Boston, MA 02114
Phone: 207/409-6502
Adam Kersnowski: 207/409-6502, sales@airworks.io

AirWorks is an AI-powered autonomous drafting software that allows firms to quickly get CAD drawings from their aerial images, shortening the current traditional process by weeks, if not months. With our AI-powered algorithms, the data files that you upload are autonomously identified and categorized such that our software can then churn out a pixel-accurate engineering plan.

Benjamin Franklin Institute of Technology
Sponsored by the MALSCE Education Trust
41 Berkeley Street, Boston, MA 02116
Phone: 877/400-2348
Leslie Tuplin: ltuplin@bfit.edu

BFIT's programs are focused on skill-building in areas that have strong workforce needs, even in an economy with higher unemployment. Beginning in summer 2022, BFIT will offer three seven-week Professional Land Surveying courses. This group of college credit-bearing courses is designed for professionals currently working in the land surveying field, but who wish to become a registered Professional Land Surveyor in Massachusetts.

Bluesky Geospatial Ltd.
808 State Road, North Adams, MA 01247
Phone: 800/359-8676
Shaun Vincent: 413/655 1458, shaun.vincent@bluesky-world.com

Bluesky Geospatial Ltd. is a Western Massachusetts-based firm providing aerial imagery acquisition, topographic, GIS & LiDAR mapping, and orthophotography throughout the Northeast. Bluesky has a Vexcel Ultracam Eagle digital camera and an Optech Galaxy aerial LiDAR sensor. We have 2 fixed wing aircraft (an Aero-Commander 500B & a King Air E90). We also have an extensive library of existing leaf-off imagery suitable for mapping or historical research.

CADNET Services, LLP
100 Carl Drive Suite 112, Manchester, NH 03103
Phone: 603/296-2376
Rick Ladd: 603/490-8656, rladd@cadnetservices.com

Your single source for CAD and IT solutions! Providing CAD software, training, implementation, and support, as well as the IT infrastructure to run your business on.

Carlson Software
33 East Second Street, Maysville, KY, 41056
Phone: 606/564-5028
Todd Carlson: 617/852-0246, tcarlson@carlsonsw.com

Founded in 1983, Carlson Software Inc. specializes in CAD design software, field data collection, laser measurement and machine control products for the civil engineering, surveying, GIS, construction, and mining industries worldwide. Carlson is proud to provide one-source technology solutions for the entire project cycle.

Javad GNSS
900 Rock Avenue, San Jose, CA 95139
Phone: 607/529-6320
Sean Joyce: 607/426-8150, jsma@frontiernet.net

Javad GNSS, Inc. designs and develops GNSS receivers for high precision survey applications with its range of Triumph products. Founded in 2005 by Dr. Javad Ashjaee and headquartered in San Jose, California JAVAD has built a reputation amongst the surveyor community for products that deliver accuracy, reliability, and quality.

Exhibitors (Continued)

Keystone Precision Solutions
1670 East Race Street, Allentown, PA 18109
Phone: 410/991-8798
Barry Latour: 603-583-7752, blatour@keypre.com
"We don't just sell surveying tools or equipment, we consult to create sophisticated solutions to our customers' problems that typically yield an improved workflow within their organizations."- George Allport, President and CEO of Keystone Precision Solutions

Maine Technical Source
494 US Route 1, Yarmouth, ME 04096
Phone: 800/322-5003
Jim Bosworth: 617/416-2647, jbosworth@mainetechnical.com
For over 45 years, Maine Technical Source, Inc. has sold, serviced, and supported surveying and precise measurement equipment to Surveyors, Engineers, and Contractors throughout New England and New York. MTS is thankful for our valued customers and looks to continue these relationships and welcome new ones bringing in the latest technology and equipment to the working professional.

National Society of Professional Surveyors
5119 Pegasus Court, Suite Q, Frederick, MD 201704
Phone: 240/439-4615
Tim Burch: tim.burch@nsps.us.com
NSPS is the voice of the surveying community for both licensed professionals and technicians in the United States and Territories. Among the priorities of NSPS is to introduce surveying to young people as an exciting geospatial career which is critical in land ownership, land planning, and land use.

Spiller's
34 Lexington Street, P.O. Box 1638, Lewiston, ME 04240
Phone: 207/784-1571
Coby Asselin: 207/784-1571, casselin@spillersusa.com
We've been catering to the needs of Engineers and Surveyors throughout New England for 55 years. We offer a wide range of Wide Format Printing and Scanning solutions to meet the needs and budget of any size office. We carry a full line of Survey Equipment, such as GPS, Total Stations, Robotics, Hybrid and Data Collection.

Topcon Solutions Store
1700 Cherry Street, Kansas City, MO 64108
Phone: 855/289-1772
Paul Carver: 508/397-4617, pcarver@topconsolutions.com
Topcon Solutions serves the AEC industry as the retail division to Topcon Positioning Systems, as well as an Autodesk Platinum Partner. The technology offerings, workflows, and productivity solutions between these two brands is why Topcon solutions is a leader in the industry. Thirteen locations, covering 20 states and growing!

Surveying Engineering Technology Program, University of Maine
Sponsored by the MALSCE Education Trust
5711 Boardman Hall, Room 232, Orono, ME 04401
A Richard Vannozzi: 617-429-7036, anthony.vannozzi@umaine.edu
The Surveying Engineering Technology (SVT) Program at the University of Maine (Orono) offers the only 100% online ABET accredited undergraduate BS in SVT in the United States. The SVT program also offers master's degrees and both graduate and undergraduate certificates, all 100% online. Visit us at umaine.edu/svt/ for more information and join the nearly 300 students currently enrolled in SVT at U. Maine.

Exhibitors (Continued)

Wachusett Survey Solutions
5 City Hall Ave, Gardner, MA 01440
Phone: 888/343-8477
Todd Varney: 617/721-7514, toddvarney@wachusettsurvey.com

Wachusett Survey Solutions is a proud reseller of survey equipment serving all of Massachusetts. Our bands include Carlson, Stonex, Geomax, Seco, and many more. Dedication to customer service and product support let us provide hassle -free solutions to our loyal customers.

Winwood Sawmill, formerly Paton's Lumbermill
1 Old Gardner Road, Winchendon, MA 01475
Phone: 978/496-7041
Andreus Ridley: 978/496-7041, winwoodsawmill@gmail.com

For over 30 years New England surveying and engineering firms have sourced hardwood grade stakes and hubs from Paton's Lumbermill in Lunenburg, Massachusetts. Our name has changed to Winwood Sawmill LLC and we strive to maintain the same level customer service and material quality.

WSP USA
100 North Parkway Suite 110, Worcester, MA 01605
Phone: 508/980-7155
Ted Covill: 508/864-1808, ted.covill@wsp.com

WSP USA is the US operating company of one of the world's leading engineering, geospatial and professional services firms. WSP is dedicated to serving local communities. We are engineers, surveyors, photogrammetrists, LiDAR and GIS professionals. WSP USA has over 10,000 employees in over 150 offices across the US, we partner with our clients to help communities prosper.

Friday, March 18, 2022

Featured Sessions

7:50 AM – 8:00 AM

Opening Remarks

Kenneth T. Strom, PLS, Director of Surveying, WDA Design Group, MALSCE Central Massachusetts Chapter President

Kenneth Strom is a licensed professional land surveyor with 36 years of experience in surveying and 14 years' experience in civil engineering design. Mr. Strom earned registration as a Professional Land Surveyor in 1992. Prior to joining WDA Design Group, Mr. Strom has worked with area land surveying and civil engineering firms as a chief surveyor/ survey office manager, civil engineering designer, and senior project manager. Mr. Strom has been involved in all types of land surveys including boundary, Land Court, title insurance (ALTA/NSPS), data collection (topographic, utilities and detail surveys), condominium, highway layout alterations, easement and right-of-way, construction layout and as-builts, and deformation monitoring. Ken has utilized various surveying equipment including total stations (manual and robotic) and data collectors, traditional and digital levels, laser levels, high-definition laser scanners, and GNSS receivers.

8:00 AM – 8:30 AM

General Session: Exhibitor Quickfire

Featuring a rapid-fire format during which convention exhibitors will provide a quick overview of the products and services they offer.

Moderator: Kenneth T. Strom, PLS, Director of Surveying, WDA Design Group, MALSCE Central Massachusetts Chapter President

8:00 AM – 9:00 AM

Breakout Session: Young Surveyors Network Meeting

Presiding: Charles G. Dexter, Survey Technician, Field Chief, Feldman Geospatial, MALSCE Young Surveyors Network Chair

Charlie is a UMO graduate with a bachelor's degree in survey, a minor in business, and has passed the FS exam. He has been with Feldman since graduating in 2012. In that time, he has spent 2 years as an instrument operator, 6.5 years as a crew chief, and recently moved into the office as a survey technician. Charlie has also been working on getting the Young Surveyors of Massachusetts started.

8:00 AM – 9:00 AM

Breakout Session: North East Surveying Societies Meeting

Moderator: J. Dan Bremser, PLS, Senior Project Manager, Hancock Associates, MALSCE President

Dan Bremser has spent the last 21 years of his 38 years surveying at Hancock Associates, serving as a Branch Manager, a partner, and currently a Senior Project Manager easing toward retirement. Dan has a Bachelor of Science in Civil Engineering from the University of Connecticut. Before specializing in surveying at Hancock, Dan's previous experience included title examination and work as a project engineer. Dan has represented clients in hundreds of public hearings before Planning Boards, Conservation Commissions, Boards of Health, Boards of Appeals, and various other boards.

9:00 AM – 11:00 AM

Concurrent Session 2A: **Workforce Development**

At the core of workforce development is training and education. Historically this has meant that the jobs had to be plentiful enough in one location to bring in training and attract workers, or the jobs and workers needed to be in close proximity to existing educational institutions. Combinations that have rarely existed in surveying. However, by accessing online education, workforce development programs, employers and prospective employees can couple jobs and workers and the necessary education simultaneously virtually anywhere. In just over three years, the University of Maine's online Baccalaureate has revolutionized undergraduate surveying education in the United States. In the same way, the University's online surveying undergraduate certificate program can be leveraged to create a robust workforce development program for surveying, in turn revolutionizing the creation of the next generation of technicians and professionals.

A. Richard Vannozzi, MS, PLS, Assistant Professor, Surveying Engineering Technology, University of Maine

Mr. Vannozzi is a graduate of the University of Maine where, in 1984, he earned a BS in Forestry and, in 2006, earned an MS in Forestry, both with a surveying emphasis. Mr. Vannozzi has taught surveying across New England since 2003. Most recently, Mr. Vannozzi joined the faculty of the Surveying Engineering Technology program at The University of Maine in the Fall of 2019 where he teaches courses across the curriculum both in the traditional classroom and on-line. He is registered as a Professional Land Surveyor in Massachusetts have been licensed first in 1988 at the age of 25. He is a Past-President of the Massachusetts Association of Land Surveyors and Civil Engineers (MALSCE) and, in 1998, was recognized as MALSCE's Surveyor of the Year.

9:00 AM – 11:00 AM

Concurrent Session 2B: **50 Ways to Improve Your Surveying Measurements**

Sponsored by Beals and Thomas, Inc.

You often encounter best practice suggestions from many sources. How many of these do you follow? Do you share these with your team that conducts the field work? Joe Paiva takes you quickly through 50 tips, techniques, and procedures that all surveyors should be following to help ensure good measurements. They include tips for blunder prevention or to reduce know errors that are easy to overlook. With one-person so prevalent how do new field techs "learn the ropes?" If you supervise or lead teams, how do you ensure everyone is "signing from the same page?" Joe's an experienced surveyor who has also taught thousands of students in field practices, worked for manufacturers, so he has some "insider" tips, as well as his own experience as a surveyor.

Joseph V.R. Paiva, PhD, Principal and CEO, GeoLearn LLC

Dr. Joseph V.R. Paiva, is principal and CEO of GeoLearn, LLC (www.geo-learn.com), an online provider of professional and technician education since February 2014. He also works as a consultant to lawyers, surveyors and engineers, and international developers, manufacturers and distributors of instrumentation and other geomatics tools, as well being a writer and speaker. Joe is an expert on instrumentation and field techniques for eliminating blunders and improving accuracy. He teaches students in undergraduate courses on the basics and advanced methods of surveying measurement, taking the principles of errors analysis into account. He enjoys speaking with surveying practitioners in an informal manner, taking ad hoc questions as they arise during his presentations.

11:15 AM – 12:30 PM

Session 3: **Reinvigorating our Profession – Perspective from the Next Generation Surveyors**

Sponsored by the MALSCE Proprietors' Council

We have heard from survey business owners, PC Members and leaders for years about our profession: challenges, successes and where they see things headed. This year we are going to provide a fresh perspective from three next-gen surveyors so we can hear their perspectives on the profession, where they want to be and how we can reinvigorate our profession for years to come. This will be an interactive session where the moderator will encourage audience questions/comments and feedback so we can get thoughts from everyone in the business – from field to office, project management, and PLS to owners.

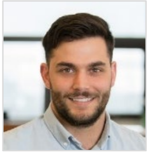
Moderator: Michael A. Feldman, President, Feldman Geospatial, MALSCE Proprietors' Council Chair

The undisputed visionary of the firm, Michael oversees everything from the daily operations to the future direction of his family-owned company. A believer in leading by example, he employs a hands-on approach with his 70-person team, ensuring that the company provides a winning and healthy culture and a great place to work. Under Michael's leadership, Feldman Geospatial has been recognized in several Boston Business Journal lists, including "Pacesetters," "Fastest Growing Companies" and as one of the region's largest family businesses. His dedication to investing in new technologies has earned the business a reputation as the go-to firm for emerging practices such as 3D laser scanning and BIM. Michael is a graduate of George Washington University in Washington, D.C. with a bachelor's degree in Business Administration. Among other things his current activities include permitting and building out Feldman's new office in Downtown Worcester.

Panelists:

Charles G. Dexter, Survey Technician, Field Chief, Feldman Geospatial

Charlie is a UMO graduate with a bachelor's degree in survey with a minor in business and has passed the FS exam. He has been with Feldman since graduating in 2012. In that time, he has spent two years as an instrument operator, 6.5 years as a crew chief, and recently moved into the office as a survey technician. Charlie has also been working on getting the young surveyors of Massachusetts started.



Shaine R. Bonin, Project Manager/Survey Technician, BSC Group, Inc.

Shaine is a Massachusetts Engineer in Training (EIT), Land Surveyor in Training (LSIT), an FAA Part 107 sUAS Pilot, and serves as a project manager as part of BSC Group's Boston-based survey team. He is a graduate student at the University of Maine, pursuing his Professional Science Master's in Engineering and Management with a focus in surveying engineering technology. He is a graduate of the University of Massachusetts Lowell, where he earned his Bachelor of Science in Engineering with a major in civil engineering. He also received an Undergraduate Certificate in surveying engineering technology from the University of Maine. Complementing his educational background is Shaine's previous experience serving as a project lead at a construction company, where he collaborated with project engineers and contractors regarding existing structure surveys, cost estimations, and plan implementations for shallow foundation construction and residential septic systems.

Sterling Hooke, PLS, Project Manager, Encompass Energy Services

Sterling is a Professional Land Surveyor currently licensed in five states (ME, RI, CT, NJ, KY). He received his bachelor's degree in Surveying Engineering Technology at the University of Maine while interning at GM2 Associates, Inc., and then was hired on full time at SGC Engineering, LLC in 2012 after graduation. At SGC Sterling worked for seven years on a range of projects throughout the eastern U.S., both field and office. Currently, Sterling works at Encompass Energy Services as a project manager and team leader, primarily dealing with ALTA/NSPS surveys in the renewable energy sector, supporting and consulting clients with the land acquisition and development process throughout the northeast.

12:30 PM – 1:45 PM

Lunch, MALSCE Annual Meeting & Awards Presentations

Presiding: J. Dan Bremser, PLS, Senior Project Manager, Hancock Associates, MALSCE President

Keynote Address: NSPS, National Surveying Advocacy, and the Future of Surveying

Like many jobs in this age of automation, the surveyor is quickly becoming an endangered profession. There are many facets in our everyday lives that are the responsibility of a surveyor, but the number of practitioners is dwindling. The pandemic may have turned our world upside down for many reasons but for surveyors, it increased our visibility and workload. Attrition will claim many within our ranks over the next several years, so we must rise together and find a way to prolong our profession through all avenues, including word of mouth, marketing, social media, and recruiting at all ages. NSPS is leading the way as the national voice and advocate for the surveying profession. We are working with legislators across the country to safeguard our professional licensing process and continuing to educate the public on the importance of our profession.

The future of surveying remains at the forefront of the NSPS list of advocacies. We recognize the challenges faced not just by surveyors but by many other professions and occupations. We also recognize that inclusion is a key component to creating diversity and we are ramping up our efforts to be more inclusive of all nationalities, races, and genders. Together, we grow as a profession and a nation. The future of surveying is very bright, and NSPS is continuing to lead the way in creating a positive career path for our future geospatial professionals.

Keynote Presenter: Timothy W. Burch, PLS, Executive Director, NSPS

Timothy W. Burch, PLS, is the Executive Director of the National Society of Professional Surveyors (NSPS). He also served as President-Elect, Vice President, and Secretary (2015-2019) of the NSPS Board of Directors, and as Governor/Director representing Illinois (2007-2014). Tim has been involved with the organization for more than 20 years as a member of the Certified Survey Technician Board, Joint Government Affairs, and ALTA/NSPS Land Title Survey committees. Along with content contributor for NSPS social media, he is creator and producer of the NSPS podcast "Surveyor Says!" and a contributing writer to the NSPS newsletter "News and Views." Tim also serves as a Brand Ambassador for the “Get Kids into Survey” initiative created by Elaine and Elly Ball and was instrumental in establishing NSPS as the North America distributor for the GKIS posters.

Tim was recently named to serve as Chair for the FIG Commission 1 – Working Group 1.1 (Professional Ethics) and will serve as Chair for the overall Commission 1 (Professional Standards) starting in 2023. He is a co-contributing editor for survey in GPS World Magazine (2015-present) and contributor to the various surveying society newsletters and blogs. Mr. Burch is a Professional Land Surveyor licensed in the States of Illinois and Wisconsin.

1:45 PM – 2:15 PM

Concurrent Session 4A: Surveying Career Slide Deck for Student Outreach

It’s never too early to start attracting the next generation of surveyors to the profession! View the presentation the MALSCE Public Awareness Committee put together to bring to local schools to teach children about land surveyors and what they do.

David Prince, PLS, Vice President Survey Services, WSP

David is a multi-state Licensed Land Surveyor with 30 years’ experience. David, who possesses an Associates Degree in Land Surveying from Paul Smith’s College (‘90) and a Bachelor’s Degree in Survey Engineering from Ferris State University (‘93), currently holds the position of New England Survey Manager for WSP USA Inc. David has spent the past 25 years with WSP working out of their NH Office but managing and overseeing projects throughout the New England / NY Region.

1:45 PM – 3:45 PM

Concurrent Session 4B: 50 Ways to Improve Your Surveying Measurements (A Continuation of Session 2B)

Sponsored by Beals and Thomas, Inc.

Joseph V.R. Paiva, PhD, Principal and CEO, GeoLearn LLC

2:30 PM – 4:00 PM

Concurrent Session 5A: **MassDOT New Engineering Directive E-21-005, Subsurface Utility Engineering (SUE): Its Impact on Mass-based Engineers, Surveyors, and the Future of the Industry**

Subsurface Utility Mapping (SUM), also known as Subsurface Utility Engineering (SUE), is an engineering discipline dedicated to locating and mapping buried facilities. This session's presenter will discuss SUM, the roles and responsibilities of the owner, engineer, and contractor in protecting subsurface utility assets and the impact the latest technology will have on investigations. He will also examine national law changes requiring SUE, MassDOT's recently released Engineering Directive E-21-005, Subsurface Utility Engineering (SUE), and how the U.S. compares to other countries making effective policy changes to improve public safety through survey practices.

Michael Twohig, Director of Subsurface Utility Mapping, DGT Associates

Michael A. Twohig is a Subject Matter Expert in the field of Subsurface Utility Mapping (SUM). Michael has more than 38 years of industry experience across the US, Australia, India, and Europe with a focus on the integration of traditional utility locating procedures with land survey best practices. As head of SUM at DGT, Michael spearheads the firm's subsurface utility locating, 3D utility mapping, and subsurface utility damage prevention programs. Michael is currently developing Multi-Sensor Mobile Mapping platforms using the next generation of multi-channel, multi-frequency Ground Penetrating Radar (GPR) systems for the SUM and void detection industry. In the span of his career, Michael has authored more than 50 articles relating to utility mapping, underground damage prevention, and utility industry best practices, and he is a frequent speaker at international conferences such as the Common Ground Alliance CGA, SPAR, Hexagon, and the international Lidar conference ILMF and GEOBIM in Amsterdam. Michael has also presented SUM best practices at military, transportation, commercial and GITA conferences. One of Michael's greatest achievements is the advancement and development and implementation of new 3D deliverables for geospatial projects, integrating LiDAR, utility locating systems, GPR, infrared, land surveying, and multi-sensor platforms to provide high quality, reliable and accurate data for CAD, GIS and BIM delivery format.

4:00 PM – 6:00 PM

Concurrent Session 5B: **Things About Instrumentation You May Have Forgotten or Never Learned**

Sponsored by Beals and Thomas, Inc.

Today's projects require the ability to assess measurement challenges and make decisions on which technology and approach best suit the needs of the client, who often do not understand what they need. Whether to deploy a solution involving geotechnical sensors, GNSS or automated total stations requires a solid understanding of what each can provide and how they can be deployed as a system to maximize effectiveness. This session will provide a generic review of some typical projects, considerations in planning projects and review of available technologies, without focusing on one brand. There will be time for questions and answers, exploration of how to fully explore equipment and software capability, and common pitfalls.

Joseph V.R. Paiva, PhD, Principal and CEO, GeoLearn LLC

Dr. Joseph V.R. Paiva, is principal and CEO of GeoLearn, LLC (www.geo-learn.com), an online provider of professional and technician education since February 2014. He also works as a consultant to lawyers, surveyors and engineers, and international developers, manufacturers and distributors of instrumentation and other geomatics tools, as well being a writer and speaker. Joe is an expert on instrumentation and field techniques for eliminating blunders and improving accuracy. He teaches students in undergraduate courses on the basics and advanced methods of surveying measurement, taking the principles of errors analysis into account. He enjoys speaking with surveying practitioners in an informal manner, taking ad hoc questions as they arise during his presentations.

4:15 PM – 6:00 PM

Concurrent Session 6A: **Structural Monitoring – Tracking Movement in a Fast-Paced World**

Today's projects require the ability to assess measurement challenges and make decisions on which technology and approach best suit the needs of the client, often when they do not understand what they need. Whether to deploy a solution involving geotechnical sensors, GNSS, or automated total stations requires a solid understanding of what each can provide and how they can be deployed as a system to maximize effectiveness. This session will provide a generic review of some typical projects, considerations in planning projects and review of available technologies, without focusing on one brand. Follow-up discussion will have time for questions and answers, exploration of how to fully explore equipment, and software capability and common pitfalls.

William T. Derry, Prof. LS, Technical Sales Engineer- Solutions, Monitoring, Leica Geosystems, Inc.

William T. Derry is licensed in PA, DE, MD, and NC and has 38 years of experience, with 24 as licensee. He formally trained as a geodetic surveyor in the USMC prior to the common availability of GPS (1984) and has a background in GNSS control, boundaries, ALTAs, structural layout, and topo. He has been a Wild Heerbrugg/Leica user since 1984 and started with Leica as a Technical Sales Engineer in June 2018.

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2022 MALSCE Convention

PDH Tracking Sheet

Name: ____________________

Organization Name: ____________________

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(All PDHs for MA unless otherwise listed.)

	Friday, March 18, 2022		
❑	**Session 2A: Workforce Development**	2 PDHs	→
❑	**Session 2B: 50 Ways to Improve your Surveying Measurements**	4 PDHs	→
❑	**Session 5A: MassDOT New Engineering Directive E-21-005, Subsurface Utility Engineering (SUE): Its Impact on Mass-based Engineers, Surveyors, and the Future of the Industry**	1.5 PDHs	→
❑	**Session 5B: Things About Instrumentation You May Have Forgotten or Never Learned**	2 PDHs	→
❑	**Session 6A: Structural Monitoring – Tracking Movement in a Fast-Paced World**	2 PDHs	→
	Saturday, March 19, 2022		
❑	**General Session: Re-Engineering Surveyors and Their Businesses**	4 PDHs	→

Do not return this form. Keep it for your records.

Coupling On-line Education with Workforce Development Initiatives

Presented by:

Anthony Richard Vannozzi, MS, PLS
anthony.vannozzi@maine.edu

Asst. Professor of Surveying Engineering Technology
University of Maine

March 18, 2022
MALSCE Convention
Leominster, MA

1

1

Abstract

At the core of workforce development is training and education. Historically this has meant that the jobs had to be plentiful enough in one location to bring in training and attract workers, or the jobs and workers needed to be in close proximity to existing educational institutions. Combinations that have rarely existed in surveying. However, by accessing online education, workforce development programs, employers and prospective employees can couple jobs and workers and the necessary education simultaneously virtually anywhere. In just over three years, the University of Maine's online Baccalaureate has revolutionized undergraduate surveying education in the United States. In the same way, the University's online surveying undergraduate certificate program can be leveraged to create a robust workforce development program for surveying, in turn revolutionizing the creation of the next generation of technicians and professionals.

2

2

NSPS Education Policy:

Education Policy

Share |

By vote of the NSPS Board of Directors on October 24, 2014, the NSPS Education Policy states:

"The official position of the National Society of Professional Surveyors shall be that a Bachelor's Degree in Surveying, Surveying Engineering, or Surveying Engineering Technology be the minimum educational requirement for licensure as a Land Surveyor in all jurisdictions."

https://www.nsps.us.com/page/EducationPolicy

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NSPS Education Policy:

Realities:

- Policy was understood to be a long-term goal;
- Licensure education requirements currently vary greatly from jurisdiction to jurisdiction;
- Intermediate steps would be practically necessary in most jurisdictions before the over-arching goal is realized in all jurisdictions.

NSPS

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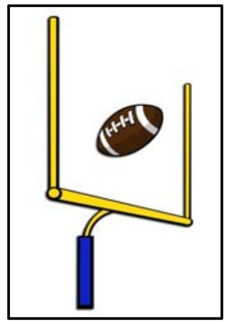
NSPS Education Policy:

Major Factors driving the realization of the policy:

- Regional approach "*White Paper*" (1974);
- Technological advances (1970's to date);
- *Body of Knowledge* publication (2011);
- NSPS 100% membership program (2014).



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NSPS Education Policy:

Regional approach white paper (1974):

- Provided the framework for creating regional BS/MS/PhD programs;
- Described a local/state focused system of AS programs to feed into these regional programs. (Note: this was written in the pre-undergraduate certificate era)


AN INTEGRATED REGIONAL APPROACH
TO SURVEYING EDUCATION

John D. McLaughlin
Fritz K. Petersohn

XIV INTERNATIONAL CONGRESS OF SURVEYORS
XIV eme CONGRES INTERNATIONALE des GEOMETRES
XIV INTERNATIONALER KONGRESS FUER VERMESSUNGSINGENIEURE
SEPTEMBER 7-16, 1974 — WASHINGTON, D. C. USA

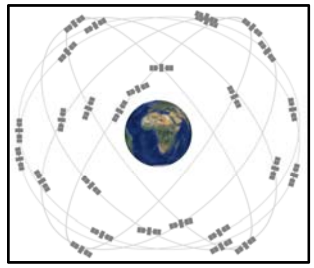
6

NSPS Education Policy:

Technological advances (1970's to date):

Pace of new technology adoption in practice outstrips historic apprenticeship/mentor education licensure model's effectiveness:

- Licensees unable to adequately provide education to mentees since they lacked knowledge themselves;
- Need for theoretical knowledge to support practice-based decision processes;
- National licensure exams moved from practice-based to knowledge-based exams.

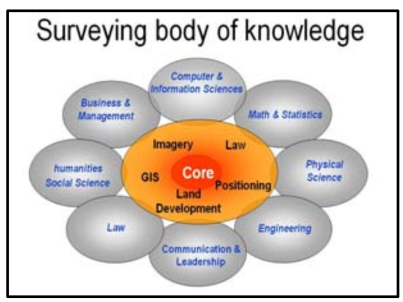


https://www.gps.gov/systems/gps/space/

NSPS Education Policy:

Articulated the basis for Surveying as a separate and distinct profession:

- Defined the breadth and depth of knowledge necessary to competently practice;
- Inescapably evident that the knowledge (quantity and quality) necessary for competent practice requires a bachelor's degree in the discipline.



NSPS Education Policy:

NSPS 100% Membership Program:

Realization that creating an educated profession was a national issue and required national leadership:

- Larger, more engaged, Board of Directors;
- Focused roll in providing support for local/state initiatives.

9

9

The Historical Surveying Educational Models

Beginning of Time until late 20th Century:

Apprentice supplemented with "informal" education

transitioned to:

Late 20th Century to today:

Formal post-secondary education and shorter experience/apprenticeship terms

10

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Brief History Lesson:

1970's-1980's Accredited BS Degrees in Surveying Engineering began popping up

1970's to date: NSPS and State Surveying Societies develop and implement numerous programs (outreach) to support, populate and grow such programs:

- Videos (e.g. *Career without boundaries*)
- Scholarships
- Trig Star
- NSPS Student Competition
- CST
- Numerous ad-hoc committees
- 2+2 Programs
- Articulation Agreements
- Regional Tuition Pacts

11

11

Brief History Lesson:

Additional Models for Surveying Education Developed:

- Associates Degree Programs
- Certificate Programs
- Minors (e.g. for Civil Engineers and Forestry)

12

12

40± Year Results:

- Continued low enrollments
- Fewer programs
- Fewer graduates
- Fewer faculty
- Nearly all programs in the US have gone through a period of instability threatening their existence.

13

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- Demand for services
- Demand for educated surveyors
- Entry level/technician personnel needs
- High salaries

??

- Low enrollments
- Fewer programs
- Fewer graduates
- Fewer faculty

Why the disconnect?

14

14

Why the disconnect?

NO! **NO!**

Education not wanted or needed?

Degree not REQUIRED for licensure?

Profession is dying?

NO! **NO!**

15

15

It's the MODEL!

How do I know?

University of Maine Surveying Engineering Technology

Spring 2019: 50ish students working on BS in Surveying Engineering Technology (traditional on-campus education)

Fall 2019, began enrolling in 100% on-line

Spring 2022: 160-ish working on BS in Surveying Engineering Technology, 100-ish working on an undergraduate (15 credit) certificate from at least 39 states and 5 countries and 30-ish Masters students.

16

16

It's the MODEL!

It wasn't that no one wanted the education, or the profession was dying, or it wasn't required, it was **ACCESS**!

Those that wanted the education couldn't get it.

#1 issue in Adult and DEI Education is removing barriers!

Issue	Solution
Day Jobs	Night School
Financial	Scholarships
Family	Campus Childcare
Transportation	Public Transportation
Geographic Remoteness	**On-line Degrees**

17

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It's the MODEL!

There is still another issue remaining:

- Most students working on degrees and certificates are gainfully employed already and happy/settled at graduation.
- Educating the existing workforce is important.
- Growing the surveying workforce is another.

18

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- Can we add on-line surveying education to existing workforce development efforts to:
  - Introduce surveying to more individuals entering the workforce.
  - Provide a pathway(s) for both technical staff and licensure that leverages on-line education and credentialing.
  - Provides access to underserved populations, those typically targeted in DEI efforts as well as our geographically isolated known demographic?

19

19

In workforce development lingo the term used is **"Pathways"**

How do you craft "pathways" for individuals that wish to explore or enter a field?

So, rather than continue trying to get high school kids to go directly into traditional on campus BS programs (It hasn't worked after nearly 40 years of intense effort)…

How about developing a supported "pathway" that tracks the actual pathway that most educated surveyors actually follow?

"Something"….to job in surveying…to surveying education…to licensure

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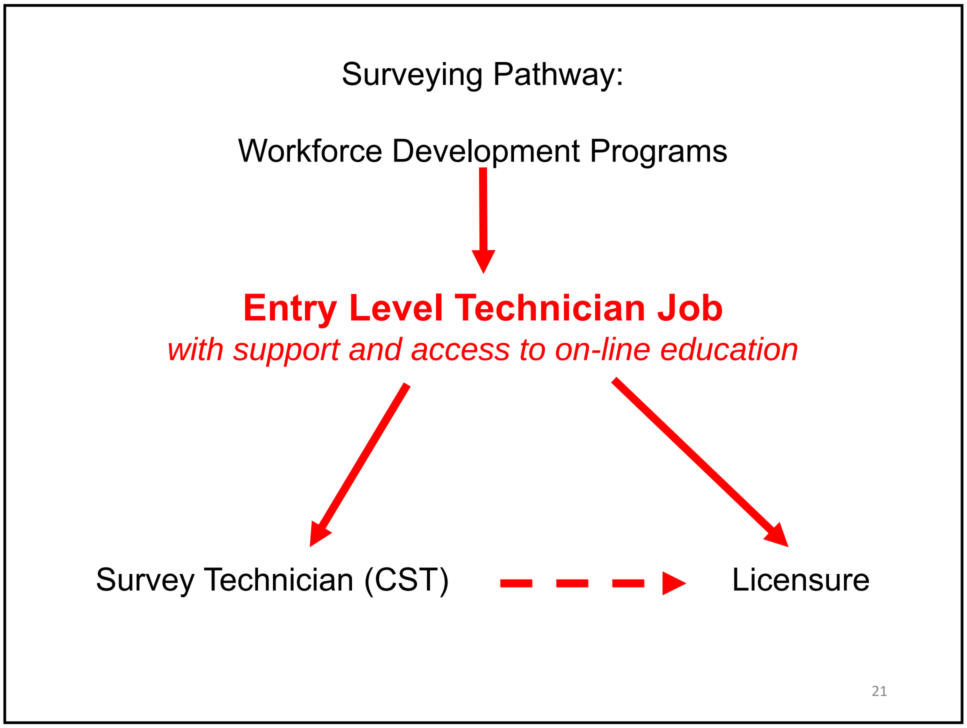
Surveying Pathway:
Workforce Development Programs
Entry Level Technician Job
with support and access to on-line education
Survey Technician (CST)
Licensure
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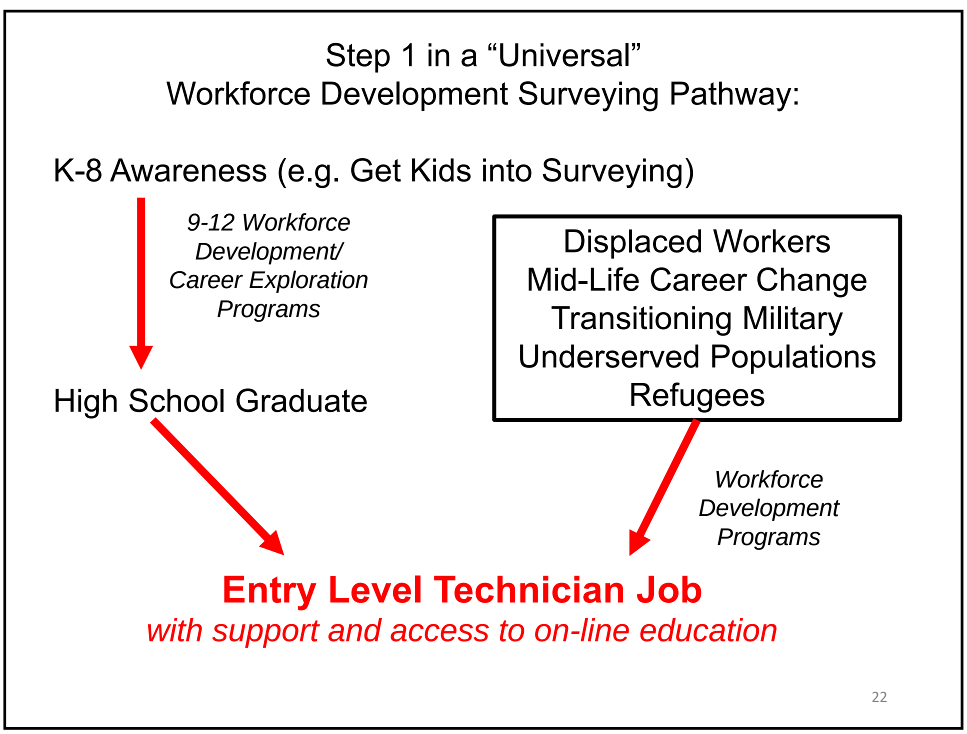
Step 1 in a "Universal"
Workforce Development Surveying Pathway:
K-8 Awareness (e.g. Get Kids into Surveying)
9-12 Workforce
Development/
Career Exploration
Programs
High School Graduate
Displaced Workers
Mid-Life Career Change
Transitioning Military
Underserved Populations
Refugees
Workforce
Development
Programs
Entry Level Technician Job
with support and access to on-line education
22

22

Prototype "K-12" Surveying **Pathway**:

- K thru 6: Age-Appropriate Awareness:(e.g. Get Kids into Surveying)
- Grades 7 thru 9: Awareness Programing in Curriculum
- Grade10 &11: Identify Interest, Mentoring, Job Shadowing, Field Trips, Speakers
- Summer between 11 and 12: Job Shadow/Internship
- Grade 12: CST Level 1 training and exam, Intro Surveying CAD class on-line apply to Certificate Program.
- Graduation, Start F/T employment, Continue education on-line

23

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On-line undergraduate certificate, baccalaureate and graduate degree programs at University of Maine

1865 THE UNIVERSITY OF MAINE

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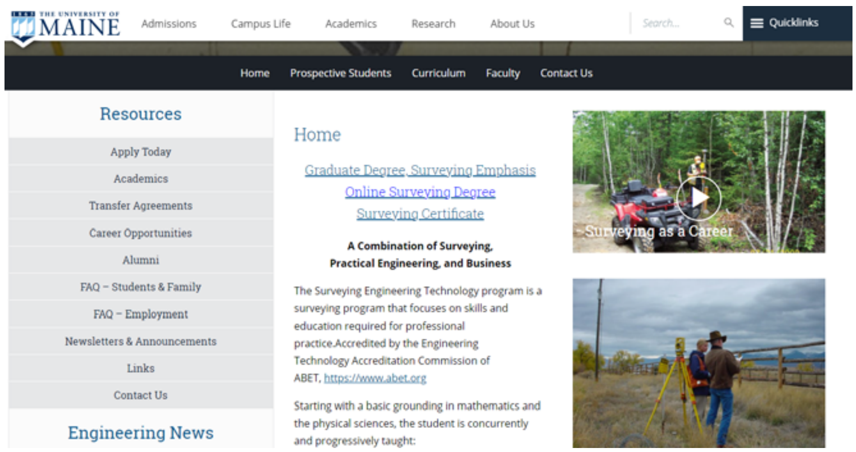
University of Maine
Surveying Engineering Technology



https://umaine.edu/svt/

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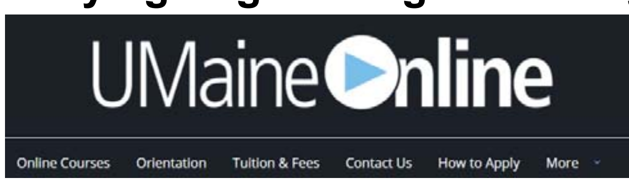
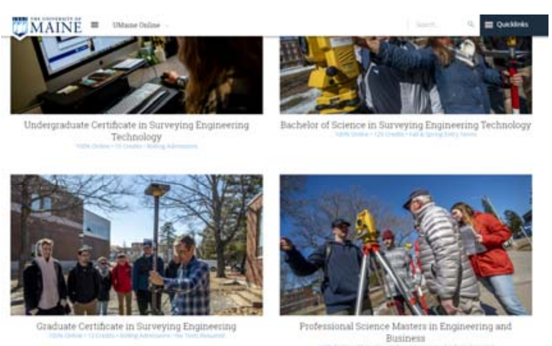
University of Maine
Surveying Engineering Technology





https://online.umaine.edu/surveying/

26

26

On-line surveying baccalaureate degree program values:

- No geographic constraints;
- National access problem is solved;
- Most direct path to body of knowledge and NSPS policy realization;
- Precursor to a Masters degree.
- (U. Maine is ETAC of ABET accredited so portability is not an issue.)

27

27

Surveying certificate program values:

- Entry credential for technicians with licensure or baccalaureate degree aspirations;
- Career change exploration;
- Viable option to fulfill education requirements in states without 4-year surveying degree requirements for licensure;
- Viable option for those with non-surveying baccalaureate to obtain discipline specific undergraduate course work;
- Precursor to an on-line degree (baccalaureate or masters).

28

28

On-line certificate ***program values (the "slam-dunk")***

- *No geographic constraints;*
- *National access problem is solved;*
- *Entry credential for technicians with licensure or baccalaureate degree aspirations;*
- *Career change exploration;*
- *Viable option to fulfill education requirements in states without 4-year surveying degree requirements for licensure;*
- *Viable option for those with non-surveying baccalaureate to obtain discipline specific undergraduate course work;*
- *Precursor to an on-line degree (baccalaureate or masters).*

29

29

Surveying UG Certificate Program:

Core Courses(9 credits):

•SVT 101: Basic Surveying Field and Office Processes (3 credits) *Fall and Spring*

•SVT 202: Route and Site Surveying (3 credits) *Fall and Spring – Prereq. SVT 101*

•SVT 221: Boundary Law (3 credits) *Fall and Spring – Prerequisite SVT 202*

Electives: two electives (6 credits). All have a prerequisite of SVT 202.

•SVT 201: Adjustment Computations (3 credits) *Offered Spring*

•SVT 331: Photogrammetry (3 credits) *Offered Spring*

•SVT 341: Advanced Surveying (3 credits) *Offered Fall*

•SVT 352: Practical Field Operations (3 credits) *Offered Spring*

•SVT 437: Practical GPS (3 credits) *Offered Fall*

30

30

Surveying UG Certificate Program Admissions Info:

Transfer Credits:
- Students will be able to transfer in up to 6 credits of similar courses from other institutions.
- Any other substitutions will be at the discretion of the surveying engineering technology program coordinator.

Requirements:
- High School Diploma or Equivalent
- Knowledge of basic trigonometry
- Ability to use a scientific calculator with trigonometry functions

Application Materials:
- An online application
- Official academic transcripts

International students may ONLY pursue this certificate online and from the country in which they are citizens.

31

31

Surveying UG Certificate Program:

Extra Courses/Credits:

Students enrolled in this certificate can take up to 21 credits at the *e-rate*.

After 21 credits, they will need to be admitted into an undergraduate or graduate degree program for the *e-rate* or *pay the out-of-state rate*.

Program	Maine and Canadian Resident or Veteran	Non-Resident*
Undergraduate – Degree Seeking	$388/credit hour	$485/credit hour
Undergraduate – Non-Degree/Not Enrolled in a Program	$388/credit hour	$1,108/credit hour
Graduate – Business	$650/credit hour**	$650/credit hour***
Graduate – Engineering***	$700/credit hour	$700/credit hour
Graduate – Education***	$550/credit hour	$550/credit hour
Graduate – All Other Programs***	$590/credit hour	$590/credit hour
Graduate Programs – Non-Degree/Not Enrolled in a Program	$541/credit hour	$1,623/credit hour

32

32

50 Ways to Improve Your Surveying Measurements

Joseph Paiva, PhD, PS, PE

2022 MALSCE Convention
Leominster

1

Another Way…

50 Ways to Screw Up Your Surveys

if you don't pay attention!

2

I Hope You Will Find This Useful

- Whether you are a business owner or senior manager
- Or are in a lower rank within your business

- If you are an owner or manager of a business, or any level supervisor, it is important to coach your teams on good processes and understanding of what they are doing.

- I hope this helps.
- My background is surveying, engineering and EDUCATION

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3

Many of These…

- You probably already know
- I'll try to refresh you on the importance of doing them…or explaining to your teams why <u>they</u> need to keep these things in mind

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4

1. Centering On a Point

- To check your plummet
- If on rotatable alidade, center on the point, before or after leveling
- Then rotate 180°
- See where the reticle lands
- If it doesn't move from original position…all good

Why?
What good is measuring an angle at a point that you didn't intend?

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Centering

- If reticle moves as you rotate, the true "aim" of the vertical axis is halfway between those two positions (assuming you rotated the alidade 180°)
- So you can still center accurately, just keep the indicated, but erroneous line of sight such that it moves in a circle around the ground point!
- If you check at 180° intervals, the two points should fall such that the true point is in the midpoint between them

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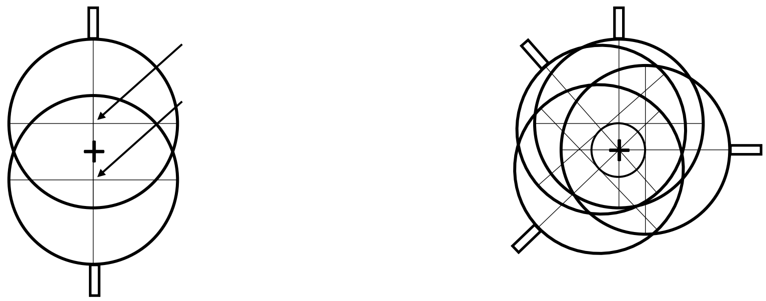
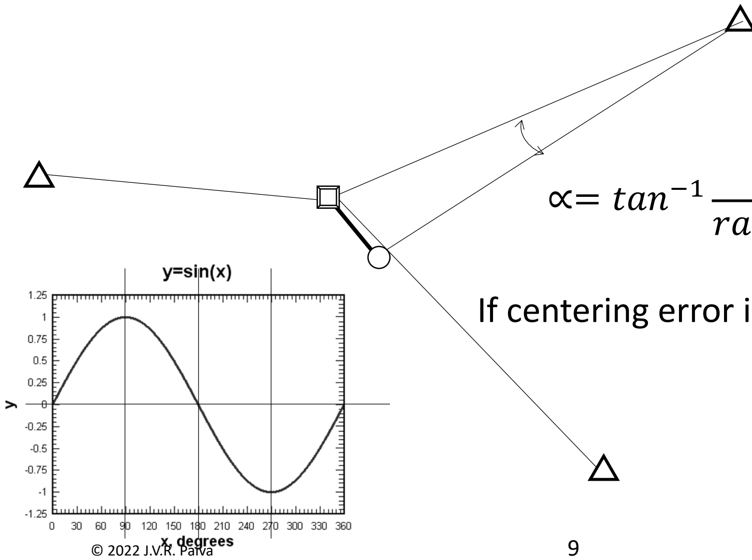
2. Correct Plumbing Point



Check and Correct For This Every Setup

- Don't wait to get it adjusted!
- Correcting for this problem is a field procedure that all technicians should follow
- No excuses… "but we didn't know how to adjust" or "no time to get it to the shop"

3. Magnitude of Mis-Centering – H. Angle

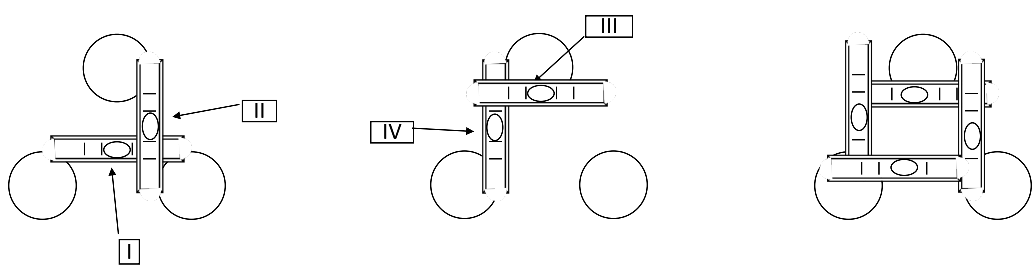


$$\propto = tan^{-1}\frac{centering\ error}{range\ to\ observed\ point}$$

If centering error is 0.02 ft and range is 100 ft,

$$\propto = 41''$$

4. Leveling



BTW: most experienced operators can center within 1/5 of span of 2 mm graduations. So, if 30" bubble, ±6" centering.

Bubble movement at III indicates TWICE the error in bubble adjustment

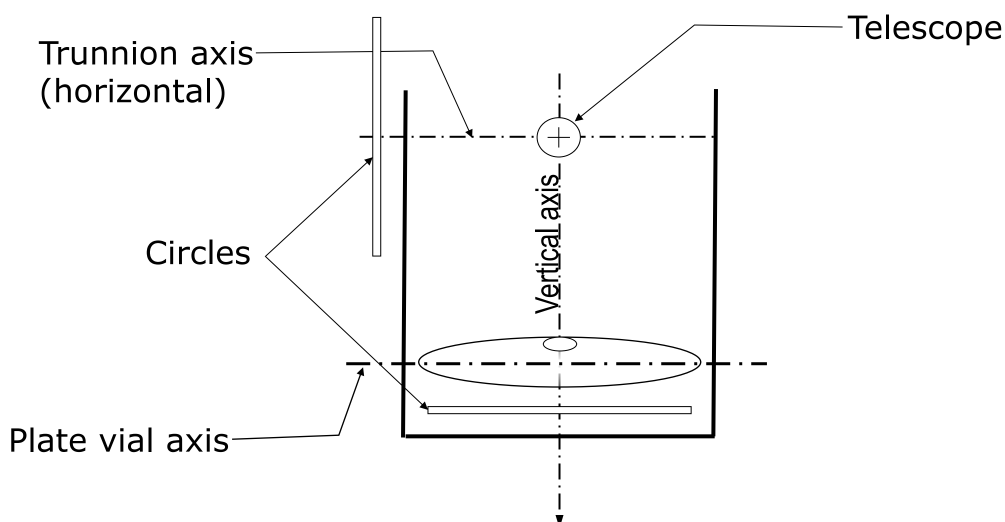
Key is to find REVERSING point…where bubble stays in same position as you rotate alidade

5. Electronic Compensator

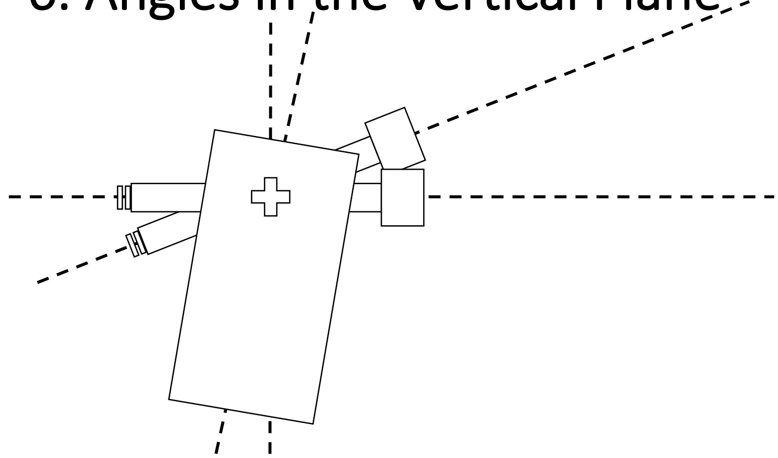
- Single axis or dual axis?
- What does this mean?

- Let's look at anatomy of theodolite

Basic Alignment of Theodolite

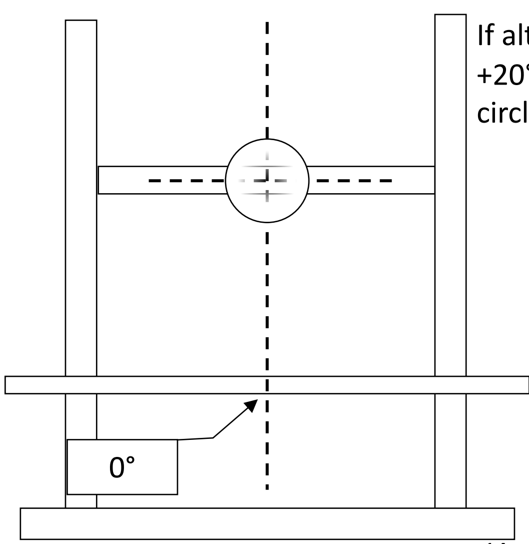


6. Angles in the Vertical Plane

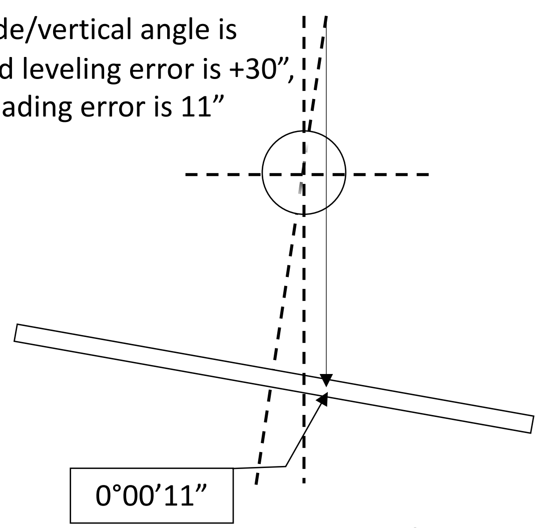


Single axis compensator corrects zenith angles for tilt of the vertical axis, i.e. in the direction that telescope points. Tilt is measured and applied to observed zenith angle.

7. Angles in the Horizontal Plane



If altitude/vertical angle is +20° and leveling error is +30", circle reading error is 11"



Solving For Error in H. Reading

- H. angle affected by tilt in direction of horizontal or transverse axis
- Error is solved with

$$E_H = \alpha tan v$$

- Where
- α is leveling error
- ν is vertical (or altitude) angle
- E.g. Leveling error is 30”, vertical angle is +20°
- $E_H = 11$” (note this is for single reading, or one direction – to measure an angle you have two readings or directions)

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8. Compensator in Adjustment?

- How to tell?
- Answer: same way you check plate bubble
- Level up (i.e. get to zero tilt) with display aligned with two leveling screws in position I
- Now rotate 90° to position II and level up
- Go back and forth until both show no error
- Now rotate to position III

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If Compensator is Out of Adjustment

- If it doesn’t show zero tilt, movement is twice the compensator error
- You can still use without adjusting compensator by using reversing point principle
- Note, if dual axis, look in both sighting and transverse axis directions on compensator display and level both in position I using all three leveling screws
- Move to position III and see the error, etc.

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9. Reversing Point

- This is the position on the plate bubble or compensator where bubble position or compensator tilt indication remains the same as you rotate alidade

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18

10. Collimation

- Is cross hair aligned with optical axis of telescope?
- How to check
- Basic procedure is get a nice clear, sharp target about 150-250 ft away (close to horizontal, i.e. Z=90°); this distance depends on quality of instrument and magnification—you may need to be only 50-75 ft away
- Level up instrument and sight at the target in F1, record H and Z readings
- Invert into F2, sight target, record H and Z readings

Interpreting Readings

- What should you observe?
- This should be obvious if you know your instrument

Collimation Check

- Example data
- F1 H = 236°14’32”, Z = 87°15’16”
- Above values should be <u>mean</u> of four to eight sightings
- F2 what should you get if it is in good adjustment?
- Again, take mean of same number of readings as in F1

Collimation Check

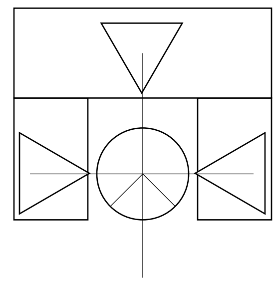
- Example data
- Mean F1 H = 236°14’32”, Z = 87°15’16”
- Above values should be <u>mean</u> of four to eight sightings
- Mean F2 H = 056°14’36”, Z = 272°44’50”

- Conclusion: variation in H is 4”, variation in Z is 6”
- H error +2” Z error +3”

11. EDM Check – Collimation (different!)

- EDM axis of measurement energy must be aligned with optical axis and reticle
- Conduct sweep test

1. Sight at prism, put cross hairs on center
2. Take distance reading
3. Now tangent to right 1 minute, take reading
4. Repeat until you get no response
5. You will see variation in distance



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EDM Collimation Check

- Now repeat same pattern to left, right, up and down
- Are you getting the most consistent readings on center?
- If not, take EDM to your <u>certified, qualified</u> instrument shop
- Make sure they have an infrared alignment scope
- They can't do this adjustment without it (they may not know how)
- Think about how you use your car, your mechanic needs to understand how your car is supposed to work

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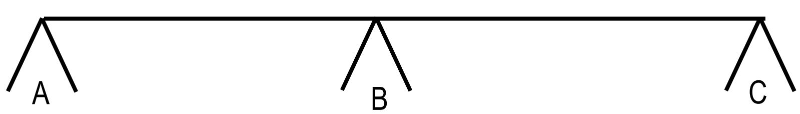
12. EDM Check – Prism Constant

- There are constant errors (fixed errors) in all EDMs
- We compensate for these with (a) an <u>instrument offset</u> (usually only set in the shop), and
- (b) <u>prism constant</u> (user settable)
- To test for the combined effect of these two error sources…
- Find a flat area about 250 ft long
- Set points at ends and middle (pacing is OK)
- Optical plummets must all be at the “no visual error” level

Determining Prism & Instrument Offsets



AB + BC should equal AC

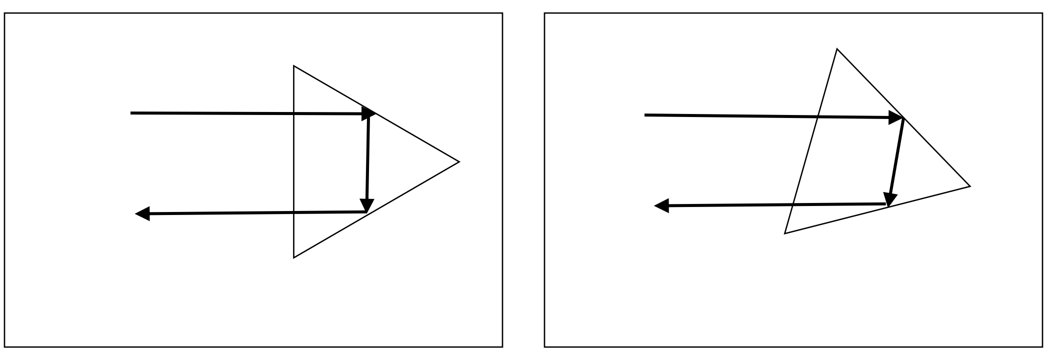
If error exists (***e***), then it will be in each
3/9/22
of the measurements, thus

AB + BC – AC = ***e***

Important Pointers

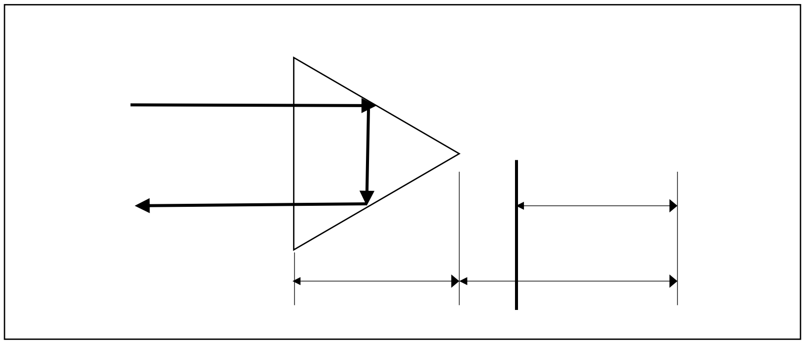
- Keep observations as flat as possible
- Use only one prism for all readings
- You can repeat with other prisms to see if you get different results
- Set your instrument to what the manufacturer tells you the prism constant is
- Any other difference is possibly due to instrument constant
- There can also be small variations in prism constants!

13. Prism Constant "Why"



Retroreflector or corner cube is not a mirror

14. Geometric Application of Prism Constant



EDM measures to a theoretical point 30 mm back of plumbing point

- Distance traveled inside prism is 2t
- Equivalent distance traveled ≈ 1.5 x 2t
- [refractive index of glass approx. 1.5]

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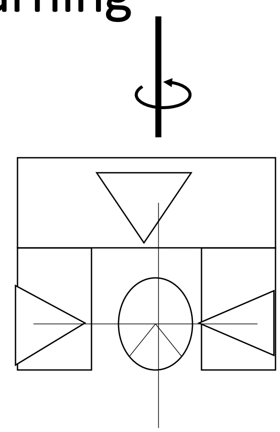
29

15. Zero Offset Prism Warning

- Don’t sight on “star”
- You will have angle error with all prism offsets (minimum with “advanced” prism offset
- It is the worst with zero offset prisms
- Affects H. and Z. angles depending on prism misalignment
- There is a smaller error on distances measured as well



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30

16. Use "Auto Pointing? How Accurate?

- OK for topo
- Check for collimation of auto pointing system by auto pointing to target
- Then check with telescope if reticle is on target (not prism, per #15!)
- Don't use auto point for traverse

17. GNSS Buffer (under trees, in canyons, etc.)

- Cannot violate laws of physics
- Most RTK systems have a display "buffer"
- Wait for system to settle before measuring an epoch or more
- Repeat occupations with "quick" RTK fixes will only reinforce the systematic error
- Set two good points in the clear (three best for redundancy)
- Then set up total station on each and calculate position of point that is shadowed

18. Faulty GNSS RTK Initialization

- RTK is not perfect
- Manufacturer's spec doesn't duplicate real life
- What's there in real life that's not in the test?
- Multipath
- Shadowing resulting in smaller number of satellites
- Latency
- Space weather
- Do you look at skyplots anymore?

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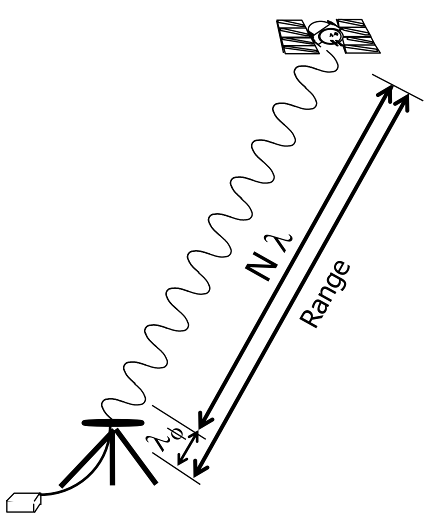
33

The Integer Ambiguity



- Receiver measures partial wavelength when it first locks on
- Partial, circularly polarized phase is read like a clock
- Receiver counts successive cycles after this
- Receiver does not know whole number of wavelengths (behind that first partial one) between it and SV

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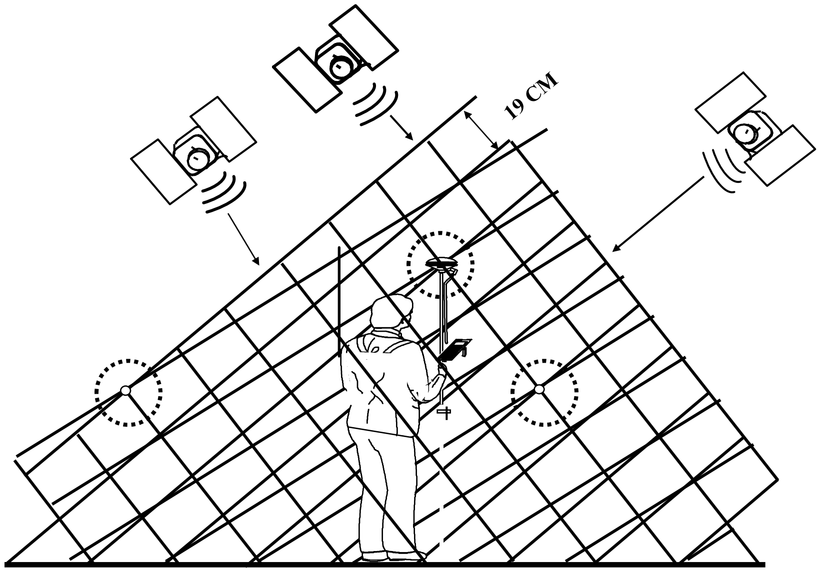
34

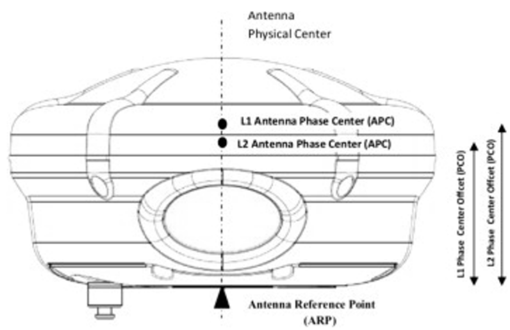
Integer Resolution

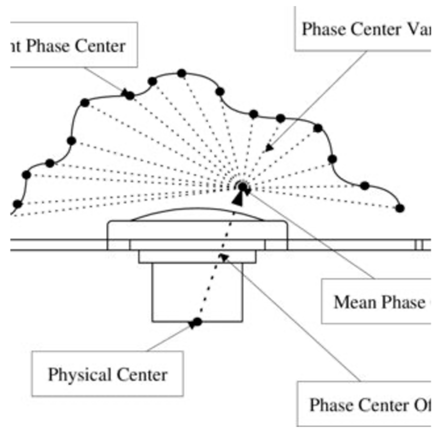


Faulty Initialization Mitigation

- Occupy all points or key points or control points more than once
- When you do the re-occupation, break lock and re-initialize
- Occupy known control set by either/and other different methods, different bases, <u>different</u> time of day; usually guarantee of different constellation
- <u>Static</u> GNSS is accurate because satellites move during observation
- Very little movement with RTK/RTN even 3-5 minute occupations

19. Know Your Phase Center Reference Mark





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37

20. Close Your Traverse

- With total station, this is easy
- Have we forgotten!
- BUT….precision can be meaningless if you've not attempted to deal with systematic errors
- Measuring all distances that are 1% too long will still give you good precision
- So don't black box it!

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38

21. Adjust Your Traverse

- Whether it is compass rule or least squares, purpose of adjustment is to mathematically, theoretically account for random error
- IT is NOT supposed to deal with systematic error
- To deal with systematic error, know your instrumentation system and the environment

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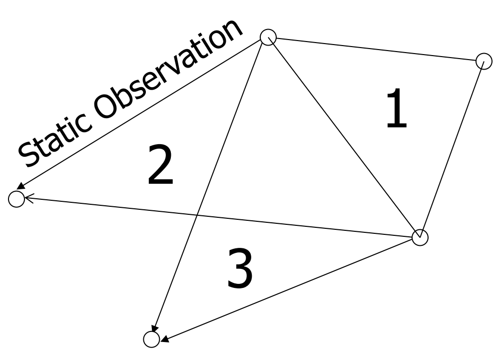
39

22. Adjust Your Static GNSS Positions



- Yes, you can traverse
- Solve the baselines that form triangles
- Now use those distances to calculate traverse triangles
- Do they add up to 180?
- Another option: proper least squares adjustments
- OPUS is great but don't take it and and use without redundancy!

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40

23. Adjust Your RTK GNSS Positions

- If you are using RTK, you are doing a radial survey
- How do you adjust your positions?
- One way is to set up a new hub for your radial measurements
- Or use RTN with redundancy
- As usual always check into known control periodically
- If possible observe at a different time to swap out the constellation

24. Total Station Angle Error

- DIN or ISO spec published by manufacturers is NOT the angle uncertainty
- E.g. instrument has spec of ±3”
- This means when you sight at a target, such as BS or FS, you have an uncertainty of ±3” standard deviation of the mean of F1 and F2 *in that direction*
- For the angle, you have two of these, so total angular error (standard deviation) is ±4.2” (i.e. $\sqrt{2}DINspec$)

A Few More Total Station Angle Random Error Examples

- $E_{\text{"doubled" angle}} = \frac{E_{spec}}{\sqrt{2}} \times 2$

No. obs. In 1 angle

No. repetitions

- For a "normal" angle in F1 and F2, n = 2
- So with 3" spec, total error = 4.2"
- What if you're shooting topo? (i.e. one F1 reading)
- $E_{F1only} = \frac{E_{spec}}{\sqrt{1}} \times 2$
- So, with 5" spec, angle error = 10 "

Calculating Total Station Angle Random Error

- General equation: $E_{gen} = \frac{E_{spec}}{\sqrt{n}} \times 2$
- For a "normal" angle in F1 and F2, n = 4 (twice in F1; twice in F2) with instrument spec of ±2"
- Random error in angle = ±2"

25. EDM Error

- Usually stated as ± (x mm + y ppm) standard deviation
- So if it is ±(2 mm + 2 ppm), realize uncertainty is variable
- Do a few test calculations
- The basic method: for 100 ft shot, start with 2 mm (0.007 ft)
- 2 ppm of 100 ft: $100 \times \frac{1}{10^6} \times 2 = 0.00005\ ft$
- Total: round up to 0.01 ft (using full precision, equivalent to 1:14,000)

Create a Table for Your Instrument(s)

This is for an instrument with accuracy ±(2 mm + 2 ppm)

Distance	Constant (ft)	Variable (ft)	Combined (ft)	Precision (1: x)	PPM
10	0.007	0.00002	0.007	1519	658
25	0.007	0.00005	0.007	3781	264
50	0.007	0.0001	0.007	7506	133
100	0.007	0.0002	0.007	14789	68
500	0.007	0.001	0.008	66124	15
1000	0.007	0.002	0.009	116801	9
2000	0.007	0.004	0.011	189365	5
3000	0.007	0.006	0.013	238823	4

26. Combining Angle and Distance Error

- Are your angles more accurate than your distances?
- Vice versa?
- How do you know?

- [Why would you want to know?]

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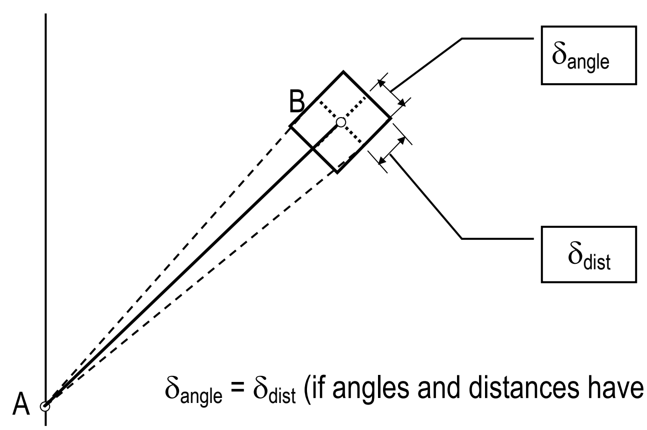
47

Angle-Distance Relationships



$\delta_{angle} = \delta_{dist}$ (if angles and distances have same uncertainty)

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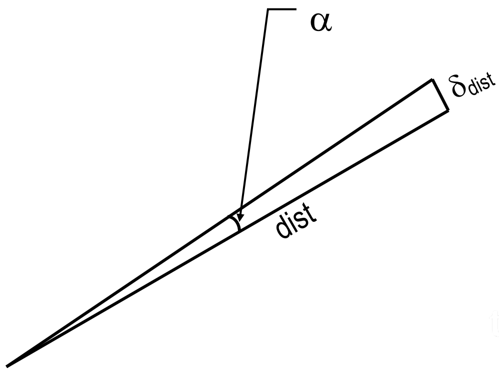
48

Angle-Distance Relationships

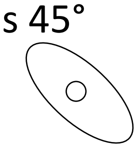


So equivalent of ±5" is 1:41,000
Distance precision of 1:25,000 is ±8"

49

27. What About Error Ellipses?

- Let's say on a particular shot you measured the angle to the point F1/F2 with a 5" instrument, so angle uncertainty is ±7"
- The distance shot is 750 ft with a ±(3 mm + 3 ppm) EDM
- The side to side uncertainty for angle is ±0.025 ft
- The in/out uncertainty is ±(0.01 + 0.002) = ±0.012 ft
- Let's say for that shot, your line of sight azimuth is 45°
- Then, error ellipse looks something like this:



50

Want to Know More?

- Check out Charles Ghilani's

"Adjustment Computations"

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Parting Thought on Evaluating Errors

- The specs are only part of your error budget
- The instrument manufacturers are not allowing for errors in centering, leveling, sighting, atmosphere, etc.
- You have to use your judgment to <u>add-on</u> to the spec'd uncertainty!
- Pretty sure bet that the errors (random and systematic) you experience with *any instrumentation* are going to be larger than the manufacturer's spec'd value

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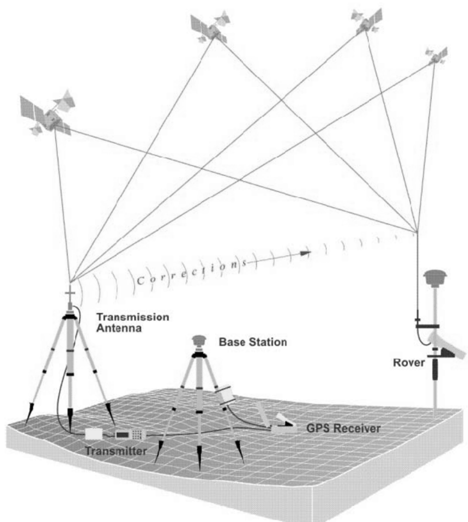
28. RTK Uncertainty



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53

28. RTK Uncertainty

- Specs are usually ±(1 – 2 cm + 1 – 3 ppm) standard deviation
- Do you know what your RTK system spec is? If not, why not?
- Where is that manual?
- 1-2 cm is easy to understand: ±0.03 to 0.07 ft
- PPM applied just like with EDM to the distance between base station and observation
- Generally, if RTN, you can assume this PPM error is negligible
- But…you must look up RTN provider's specs for uncertainty—if not given, demand it!

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54

BTW: Check on RTN Health

- Best way: have reliable points (minimum of three)
- Observe them with RTN
- Develop your allowable variations from what you believe are the control values
- Have a systematic plan for evaluating and then deciding whether to use RTN that day (or week, or hour or …)

29. Checking Between Two Monuments

- You are told that the distance between two monuments (A and B) is 4,529.32 ft
- Uncertainty at A, 95% confidence is ±0.15 ft
- Uncertainty at B, 95% confidence is ±0.20 ft
- With your static GNSS system you measure this line and get a number, but it doesn't match
- GNSS spec is ±(1 cm + 2 ppm) standard deviation
- How to figure out whether your number fits?

Uncertainty in Your Control

- Random error combines as the square root of the individual terms squared and summed, in other words
- $E_{total} = \sqrt{E_1^2 + E_2^2 + \cdots \cdots E_n^2}$
- So for line AB, based on published uncertainty we can expect uncertainty in the distance to be $\sqrt{0.15^2 + 0.20^2} = 0.25$ ft
- This is at the 95% confidence level
- If we want std deviation, 68% confidence, we divide by 2 (actually 1.96, but OK to round to 2), so $\sigma = 0.125\ ft$

But Our Measuring System is Not Perfect

- It has defects, and in fact the manufacturer tells us that each position determined with a receiver has an uncertainty of ±(1 cm + 2 ppm), which converts for this distance to
- 0.033 + 0.009 = ±0.042 ft per end point with 68% confidence
- So our result has uncertainty of $\sqrt{0.042^2 + 0.042^2}$
- This can be simplified, if you wish, to $\sqrt{2} \times 0.042 = 0.059\ ft$
- So your "measuring tape" you've stretched between A and B has an uncertainty of 0.059 ft at 68% confidence

…And Our Control is Not Perfect

- Our control is only good to 0.125 ft standard deviation
- To figure out how much our measured distance should fit within, we use the same equation again
- $uncertainty\ of\ fit = \sqrt{0.125^2 - 0.059^2}$ = 0.11 ft
- So we can have a measurement that is within the range of ±0.11 ft of the inversed distance between control of 4529.32 and still call it good!

30. Using Least Squares

- Don't simply plug in specifications of your manufacturer
- Their numbers are "ideal" and not always written the way you work, i.e. the direction vs. angle definition for angle accuracy
- But look at your whole system
- How are you centering? Is it accurate?
- How are you leveling is it accurate?
- What about tribrach O.P and prism pole bubble?

What About…

- Prism constant
- Instrument constant
- Optical plummet on tribrach
- Heating/cooling of instrument
- If the line is long enough, are you considering temperature and atmospheric pressure?
- Is the (tripod, etc.) setup stable?
- How long does it take to collect your measurement?

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61

What About…

- Vibrations from construction, traffic, trains, foot traffic
- Frozen ground, windy day
- Warping of the instrument from sunshine
- Do you let the sunlight directly hit your bubble/compensator?
- All these factors affect the uncertainty level you should plug into your least squares software
- If you haven't done the experiments to determine impact from these factors at least use factor of safety of 2 – 5 (YES)!

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62

31. Impact of Atmospheric Temperature on EDM

- Normal response is "PPM is so small, I can ignore it"
- Or "I just put in X°"
- What is the impact of temperature?
- Well...start by looking up the temperature at which no correction is required [you should know this]
- It is 68°F on many instruments, 32°F on others, etc.
- Change in a distance due to temp is 1 ppm for approximately every two degrees Fahrenheit (more closely 1 ppm per 1°C) away from the standard temp

Calculating Temp Effect

- Light goes through atmosphere faster as temp goes up and atmosphere gets thinner
- Thus when it is hot, you get a shorter distance on the EDM than it really is
- So the correction is to ADD 1 ppm for every two degrees warmer and SUBTRACT if colder
- Standard temp is 68°F, surveying at 108°, Δ = +40°
- Therefore impact is ≈20 PPM

Calculating Temp Effect

- If the distance being measured is 1000.00 reported by EDM with PPM set to 0
- The error is 0.04 ft
- You would add this number to the displayed value

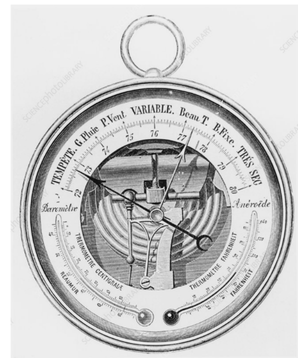
- Note: use thermometer IN THE SHADE, approximately at the height of your total station telescope, NOT your phone, bank sign, radio, weather bureau report, etc.

32. Impact of Atmospheric Pressure on EDM

- Impact: about 10 ppm per inch of Hg, actually 1.1 inch
- Pressure also changes (lessens) about 1 inch for every 1000 ft
- When pressure is high, air is thicker, so light travels through it slower
- So displayed distance will be longer and correction will have to be SUBTRACTED
- When pressure is low, air is thinner, so ADD correction to displayed value

Calculating Pressure Effect

- What is standard pressure?
- 1 atmosphere = 14.7 psi = 29.92… inches Hg
  = 760 mm Hg = 1,013.25 millibars (mbar)
  = 101.325 kilopascals
- If pressure is 29.0”, then PPM is $0.92 \times 10 = 9.2\ PPM$
- Pressure has dropped, so add 9.2 ppm to displayed value



Calculating Pressure Effect

- Use barometer!
- NOT your phone, bank sign, radio, weather bureau report, etc.
- Electronic devices now available for phone, phone apps and stand alone handhelds
- All instruments used for pressure must be periodically calibrated against a mercury barometer

Final Word on Atmospheric Pressure Measurements

- Do not use weather reports; they report pressure as if the barometer is set up at sea level, even if you are in Denver
- That information is useless for correctly applying pressure correction
- Weather station might report 29.92” of Hg but the pressure at the surface in Denver will be about 5” lower!
- At altitude the elevation dominates over atmospheric pressure changes day-to-day (with some caveats)

33. Tribrach Circular Bubble Adjustment

- Put instrument in tribrach
- Level up properly using reversing point if needed
- Inspect circular vial
- If not centered, adjust bubble to center
- That’s it (after repeating it to refine and/or check)
- Remember the circular bubble has a sensitivity of only about 8-10 minutes per 2 mm
- Your total station vial has a sensitivity in the range of 20 – 40 seconds per 2 mm

34. Optical Plummet on Tribrach

- Either optical or laser
- Equipment: tripod, "hockey puck," tribrach AND the tribrach you are checking/adjusting
- Set up tribrach on tripod indoors, firm footing, but leveling not needed
- Put hockey puck in tribrach, then tribrach to be checked upside-down on hockey puck
- Observe mark on ceiling with reticle, rotate tribrach 180°
- Any observed movement is TWICE the error in the plummet

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71

Adjusting Optical Plummet

- You may need adjusting pin, Allen wrench or screw driver
- You can mess it up!
- May be better to take it to your service shop
- This way, if they strip the screw, they've got the parts!

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72

Better Option Instead of O.P. Tribrachs

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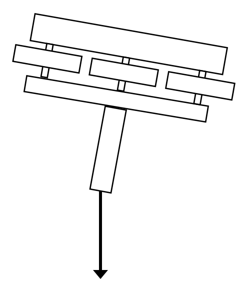
73

34. Field Check of O.P. Tribrach

- Use plumb bob
- This is only approximate as it hangs from hook on tripod fixing screw
- 1-2 cm of error is possible
- Take a lot of care to “eyeball” tripod head



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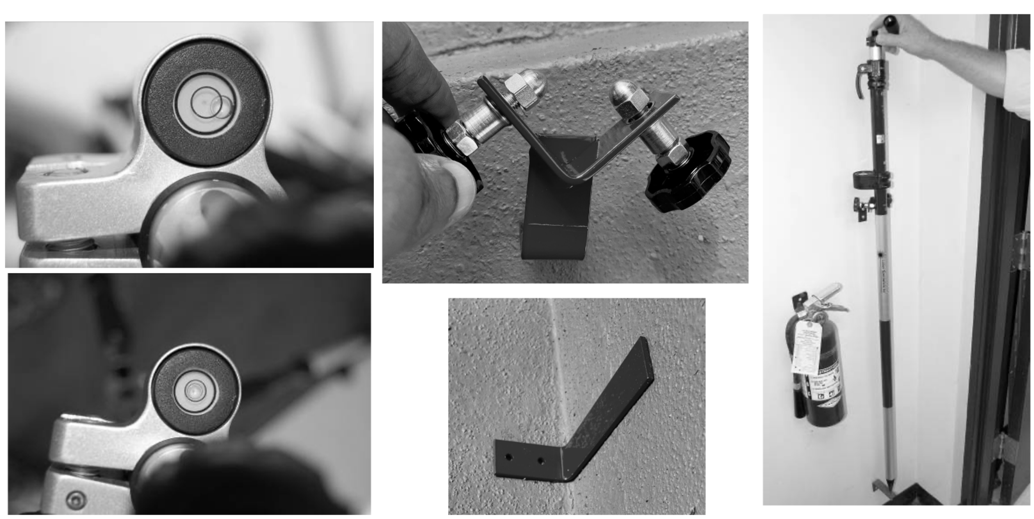
74

35. Field Check of O.P. Tribrach (#2)

- Center on point
- Trace outline of tribrach
- Rotate 120°, check O.P.; note difference
- Rotate 120° again, check O.P.; note difference
- If no difference, all is good
- If there are differences true point is at the center of the triangle formed by the three points where reticle projected to ground point

75

36. Prism Pole Bubble Check and Adjust

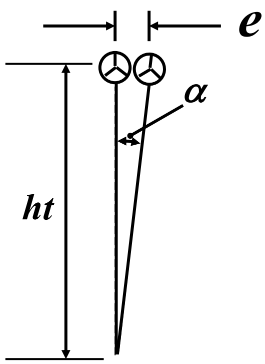


76

37. Field Check of Prism/Antenna Pole

- Find any pair of planes that come together at 45° to 90°
- Indoors this might be desk and desk drawer (pulled out)
- Outdoors this might be tailgate of truck and bumper
- Carpet is preferred indoors
- Smooth surface if outdoors, not too soft, not too hard
- Align pole with two surfaces, place point on the ground such that bubble is centered
- Carefully rotate pole 180°; any movement is twice the error

Importance of Prism Pole Circular Vial Adjustment



$$\alpha = \tan^{-1}\frac{e}{height}$$

$$e = height \times \tan\alpha = 6\,ft \times \tan 30' = 0.052\,ft$$

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38. Serialize Your Peripherals

- To keep track of equipment condition, apply permanent labels or engrave inventory numbers on any components that don’t already have an easily observable serial number: tribrachs, individual prisms, prism poles, tripods, etc.
- Put I.D. tags/flags with permanent inventory numbers on smaller parts like cables

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80

39. Have a Record Book

- Record purchase date, item description, who purchased from
- For major equipment, one page per item
- You can group prism poles, etc. several to a page, but only after you've serialized them
- Have supplementary paper field book in truck to record instrument issues, adjustments, errors as well as other survey related items – not enough to document on your phone

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81

40. Scheduled Inspection and Maintenance

- Check total station top to bottom once a month; record results
- Optical plummet and plate bubble or electronic bubble should be checked on every set up
- H and Z collimation angle check should be done once/day
- EDM tests such as "sweep" test and auto point test once/mo
- Prism pole check once/week
- Optical plummet check once/mo, if rough duty once/week

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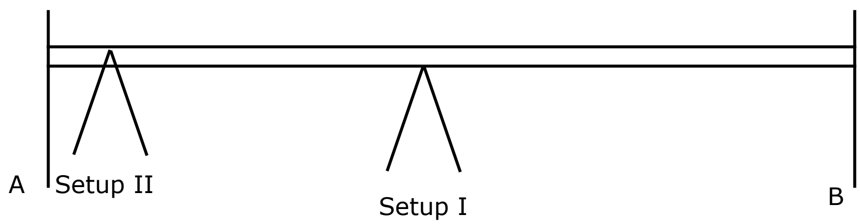
82

41. Level Two Peg Test & Adjustment



- Setup I in middle gives true Δ elev
  - If BS on A is 5.00 and FS on B is 6.00, Δ elev = 1.00
- Setup II is *very* close to A
  - If BS on A is 5.45 and FS on B is 6.35, is the line of sight high or low?
  - What should it be adjusted to?

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42. Using Steel Tape to Calibrate EDM

- Don’t do it!
- Enough said

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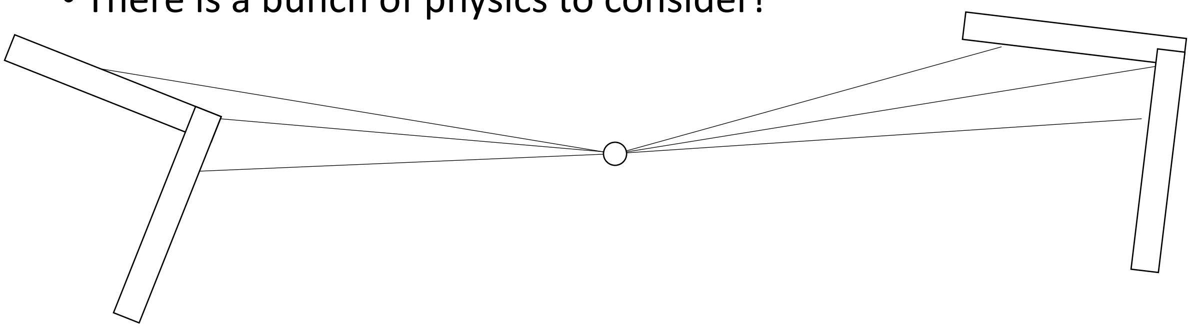
43. Prismless EDM

- Just because you put the reticle on a corner doesn't mean the technology is capable of measuring just to that corner
- There is a bunch of physics to consider!

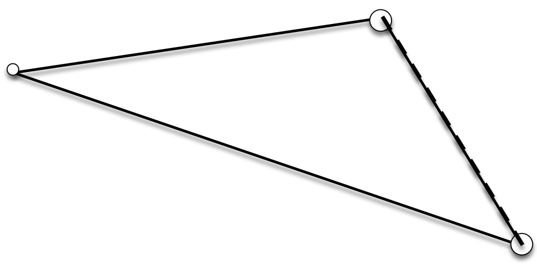


44. GNSS Principles to Remember

- Network design
- Meaningless measurements because they are NOT independent
- Most flagrant errors caused by not understanding that GNSS does NOT directly measure rover's position—it resolves VECTOR between base and rover

45. Static GPS Independent Baselines

- Biggest blunder is not having independent observations (after blunder of not setting up on correct point)



3 receivers; 1 session

Only 2 independent baselines

One more session with 2 receivers

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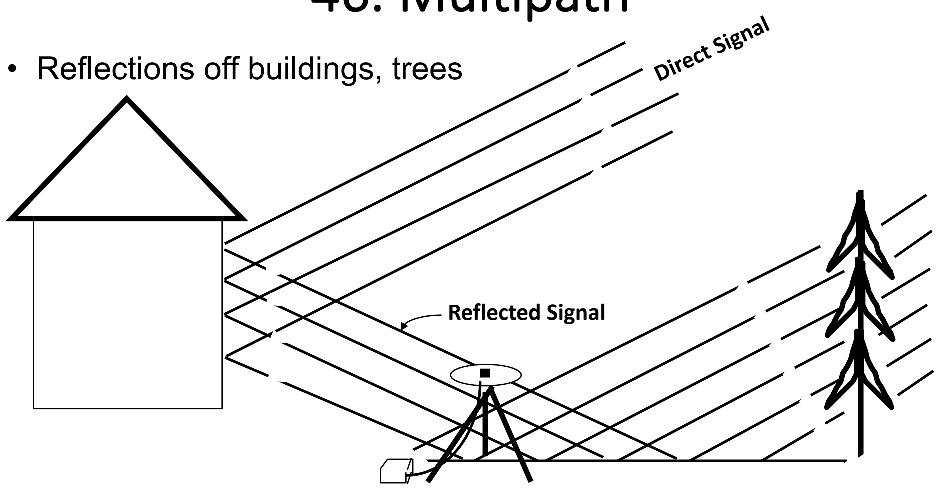
87

46. Multipath

- Reflections off buildings, trees



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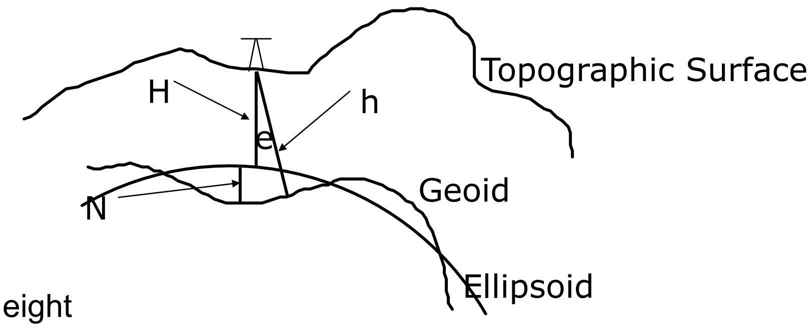
88

47. Geometric Relationships



H = Ellipsoid Height
h = Orthometric Height
N = Geoid Undulation

H = h + N
e = Deflection of the vertical

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89

48. Coordinate Systems

- GPS measures in WGS-84 Cartesian
- Surveyor could be using SPCs, UTMs, other systems—*never* WGS-84
- Converting from "native" GPS system to surveyor's system can be fraught with errors (and mistakes)
- "Localization," "calibration," "transformation" add problems of their own

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49. Tripods

- Easily forgotten
- Easily fixed
- Match the tripod to the job
- Be aware of the weak points: hinges, clamps, shoes, head
- Look at your tripod carefully to identify where components can loosen, shift, etc.

50. Unmanned Airborne Systems

- Most common blunder—not enough ground control and no or not enough check points
- Check points cannot be used to confirm the result unless you have independent check points
- Automatic exposure
- Auto focus
- Use of "easy" button too much
- Assumption that results are always good

Other Issues

- Targets to large or too small—must be sized based on ground sampling distance (GSD)
- Non-prime lenses, i.e. zoom lenses are a BAD idea
- Not focused to infinity
- Clouds
- Shadows where it is critical to have good matching

93

Other Drone Issues

- Not understanding the photogrammetric process, i.e. shortcomings
- Insufficient ground control quality
- Insufficient ground truthing
- Digital scaling up of small scale map/model

94

The Aircraft

- Test flight control components
- Pay attention to winds (vibration and excess speed)
- Insufficient accuracy of GNSS or autopilot creates gaps
- Target: all points must be imaged 12-15 times

RTK PPK or Ground Control

- RTK is fine
- But still have check points and some limited ground control
- PPK is fine, but know what you are doing and that data is being fully logged

SO…

☺

The Fancier It Gets, the Harder It Is

- When a steel tape breaks, you know about it, and how to respond to it
- When your EDM, total station, GPS, LiDAR, drone, etc. malfunctions, how to detect?
- What to do about it?
- Black box technology requires more, not less, knowledge about the technology, how it works and how to defend against erroneous or spurious data

Thank You!

- Questions: write joepaiva@geo-learn.com

geolearn

About seminar presenter Joseph V.R. Paiva

Dr. Joseph V.R. Paiva, is principal and CEO of GeoLearn, LLC (www.geo-learn.com), an online provider of professional and technician education since February 2014. He also works as a consultant to lawyers, surveyors and engineers, and international developers, manufacturers and distributors of instrumentation and other geomatics tools, as well being a writer and speaker. One of his previous roles was COO at Gatewing NV, a Belgian manufacturer of unmanned aerial systems (UAS) for surveying and mapping during 2010-2012. Trimble acquired Gatewing in 2012. Because of this interest in drones, Joe is an FAA-licensed Remote Pilot.

Selected previous positions Joe has held includes: managing director of Spatial Data Research, Inc., a GIS data collection, compilation and software development company; senior scientist and technical advisor for Land Survey research & development, VP of the Land Survey group, and director of business development for the Engineering and Construction Division of Trimble; vice president and a founder of Sokkia Technology, Inc., guiding development of GPS- and software-based products for surveying, mapping, measurement and positioning. Other positions include senior technical management positions in The Lietz Co. and Sokkia Co. Ltd., assistant professor of civil engineering at the University of Missouri-Columbia, and partner in a surveying/civil engineering consulting firm.

Joe has continued his interest in teaching by serving as an adjunct instructor of online credit and non-credit courses at the State Technical College of Missouri, Texas A&M University-Corpus Christi and the Missouri University of Science and Technology. His key contributions in the development field are: design of software flow for the SDR2 and SDR20 series of Electronic Field Books, project manager and software design of the SDR33, and software interface design for the Trimble TTS500 total station.

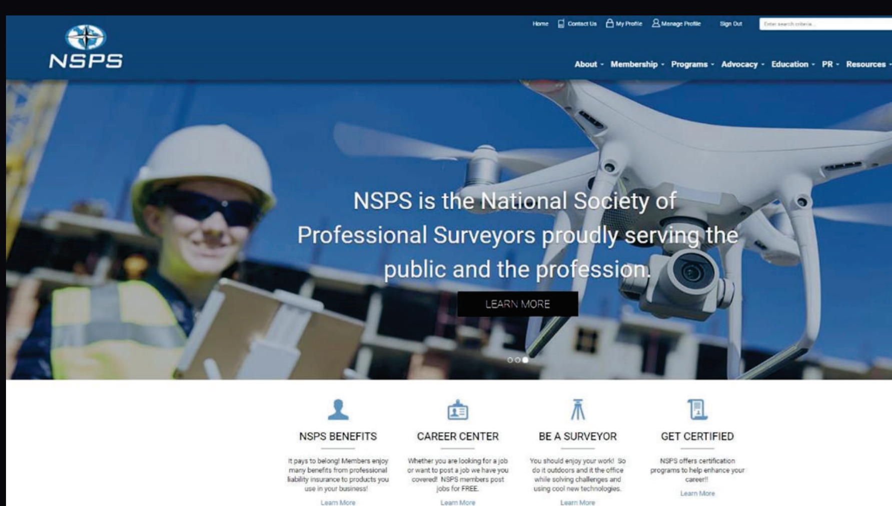
He is a Registered Professional Engineer and Professional Land Surveyor, was an NSPS representative to ABET serving as a program evaluator, where he previously served as team chair, and commissioner, and has more than 30 years experience working in civil engineering, surveying and mapping. Joe writes for *POB*, *The Empire State Surveyor* and many other publications and has been a past contributor of columns to *Civil Engineering News*. He has published dozens of articles and papers and has presented over 150 seminars, workshops, papers, and talks in panel discussions, including authoring the positioning component of the Surveying Body of Knowledge published in *Surveying and Land Information Science*. Joe has B.S., M.S. and PhD degrees in Civil Engineering from the University of Missouri-Columbia. Joe's past volunteer professional responsibilities have included president of the Surveying and Geomatics Educators Society (SaGES) 2017-19 and various *ad hoc* and organized committees of NSPS, the Missouri Society of Professional Surveyors, ASCE and other groups.

GeoLearn is the online learning portal provider for the Missouri Society of Professional Surveyors, and surveying professional societies in Kansas, New York, Texas, Pennsylvania, Wisconsin, Arizona and Oklahoma. More organizations are set to partner with GeoLearn soon.

Dr. Paiva can be reached at joepaiva@geo-learn.com or on Skype at joseph_paiva.

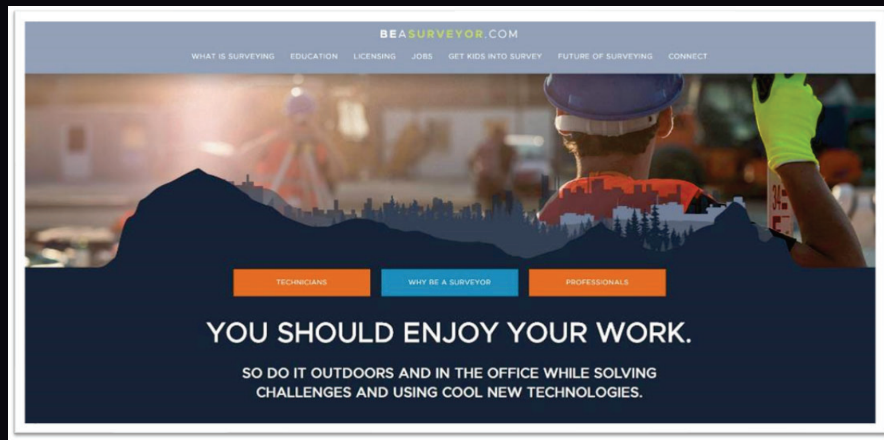
Apr 2021

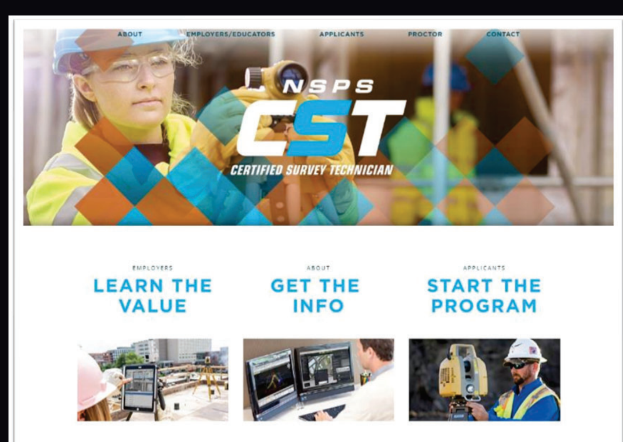
The Power of Membership in YOUR National Surveying Society



The Power of Membership in YOUR National Surveying Society

The Power of Membership in YOUR National Surveying Society





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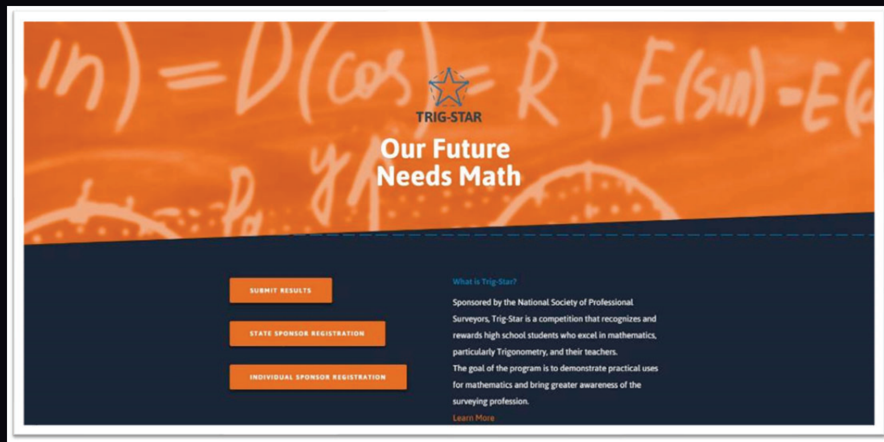


The Power of Membership in YOUR National Surveying Society

NSPS | NSPS CST CERTIFIED SURVEY TECHNICIAN | TRIG-STAR

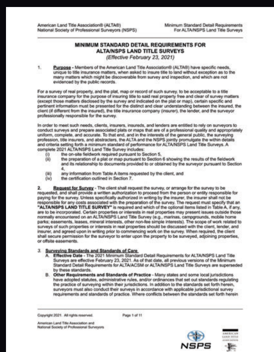
ADVOCACY

The Power of Membership in YOUR National Surveying Society

NSPS | NSPS CST CERTIFIED SURVEY TECHNICIAN | TRIG-STAR

STANDARDS

ALTA & NSPS - 60 YEARS AND COUNTING

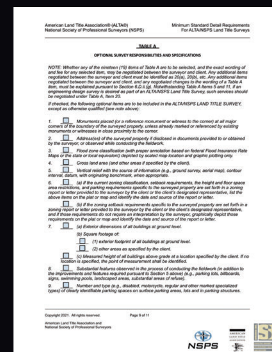

American Land Title Association® (ALTA®)
National Society of Professional Surveyors (NSPS)
Minimum Standard Detail Requirements For ALTA/NSPS Land Title Surveys
MINIMUM STANDARD DETAIL REQUIREMENTS FOR ALTA/NSPS LAND TITLE SURVEYS
(Effective February 23, 2021)

ALTA/NSPS STANDARDS UPDATE

WE NOW HAVE A NEW SET OF ALTA/NSPS STANDARDS, BUT...THEY ARE NOT EFFECTIVE UNTIL FEBRUARY 23, 2021.

During the transition period, surveyors may encounter situations whereby they have entered into a contract to perform an ALTA/NSPS Land Title Survey prior to the effective date of the 2021 Standards (February 23, 2021), but the survey is not anticipated to be completed until after February 23, 2021. In such cases, the surveyor may discuss this with the client, title company and lender and include an appropriate clause in the contract, viz., "This survey will be prepared using the 2016 Minimum Standard Detail Requirements for Land Title Surveys as established by ALTA and NSPS since said standards are still currently in effect at the time of this contract. It is understood and accepted by all parties involved that said standards may no longer be current upon completion of the survey, but will still be used for the purpose of this survey."

WWW.NSPS.US.COM/PAGE/2021ALTA
WWW.NSPS.US.COM/PAGE/2021FAQS


American Land Title Association® (ALTA®)
National Society of Professional Surveyors (NSPS)
Minimum Standard Detail Requirements For ALTA/NSPS Land Title Surveys
TABLE A
OPTIONAL SURVEY RESPONSIBILITIES AND SPECIFICATIONS

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NSPS CST CERTIFIED SURVEY TECHNICIAN TRIG-STAR

STANDARDS

PAVING THE WAY TO UNIFORM GUIDELINES

NCEES

XXVII FIG CONGRESS
AUGUST/SEPTEMBER 2022
Warsaw, Poland
Volunteering for the future – Geospatial excellence for a better living

NIST

NATIONAL GEODETIC SURVEY

IES INTERNATIONAL ETHICS STANDARDS

FEDERAL AVIATION ADMINISTRATION

The Power of Membership in YOUR National Surveying Society

NSPS CST CERTIFIED SURVEY TECHNICIAN TRIG-STAR

EDUCATION

RESOURCES FOR FUTURE SURVEYORS

ABET Computing & Engineering Accreditation Commissions

NCEES

The Power of Membership in YOUR National Surveying Society

NSPS — NSPS CST CERTIFIED SURVEY TECHNICIAN — TRIG-STAR

PROMOTION

FINDING OUR NEXT GENERATION OF SURVEYORS

FIG YOUNG SURVEYORS

YSN Young Surveyors Network

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NSPS — NSPS CST CERTIFIED SURVEY TECHNICIAN — TRIG-STAR

PROFESSIONAL COLLABORATION

WORKING WITH LIKEMINDED PROFESSIONALS

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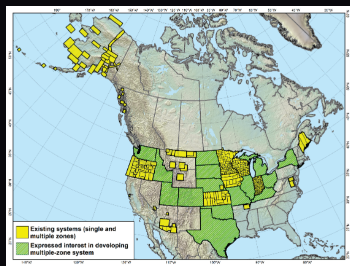
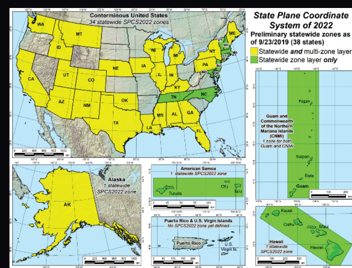
CERTIFICATION PROGRAMS

ADVANCING THE PROFESSION THROUGH GROWTH

The Power of Membership in YOUR National Surveying Society

UPCOMING NGS DATUM CHANGES





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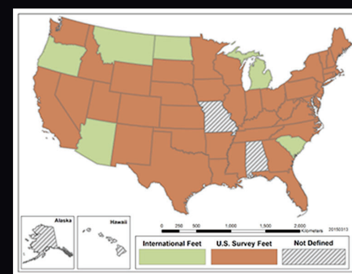

NSPS CST TRIG-STAR

NSPS BOOTH @ ASCA 2019 - BOSTON

AMERICAN SCHOOL COUNSELOR ASSOCIATION

NEXT EVENT:
JULY 2022
AUSTIN, TEXAS

"THIS IS THE BEST CAREER FOCUSED ELEMENTARY SCHOOL MATERIAL I HAVE EVER SEEN"

Rebecca Lallier
Hartford School District
Vermont

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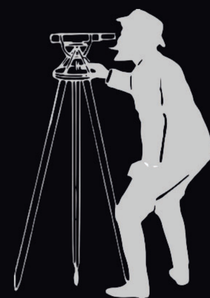
NSPS CST TRIG-STAR

THIS IS NOT THE FUTURE OF SURVEYING



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NSPS CST TRIG-STAR

THIS IS THE FUTURE OF SURVEYING

YSN Young Surveyors Network

NSPS CST TRIG-STAR

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NSPS - SOCIAL MEDIA STYLE!

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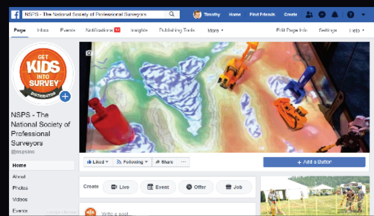

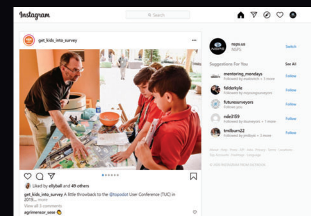

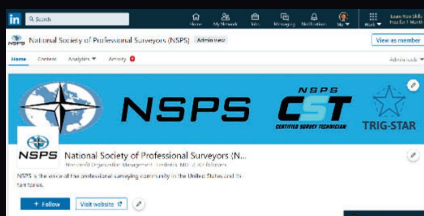

47,000 Downloads

112 Episodes

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The Power of Membership in
YOUR National Surveying Society

PLEASE LET US KNOW IF YOU HAVE ANY QUESTIONS!

Timothy W. Burch, PLS
NSPS Executive Director
tim.burch@nsps.us.com
Office: 240.439.4615
Cell: 773.329.0189


THE LAND SURVEYING PROFESSION
High School or Community College Name
Prepared by the MALSCE Public Awareness Committee
MALSCE
Presentation on 03/18/2022

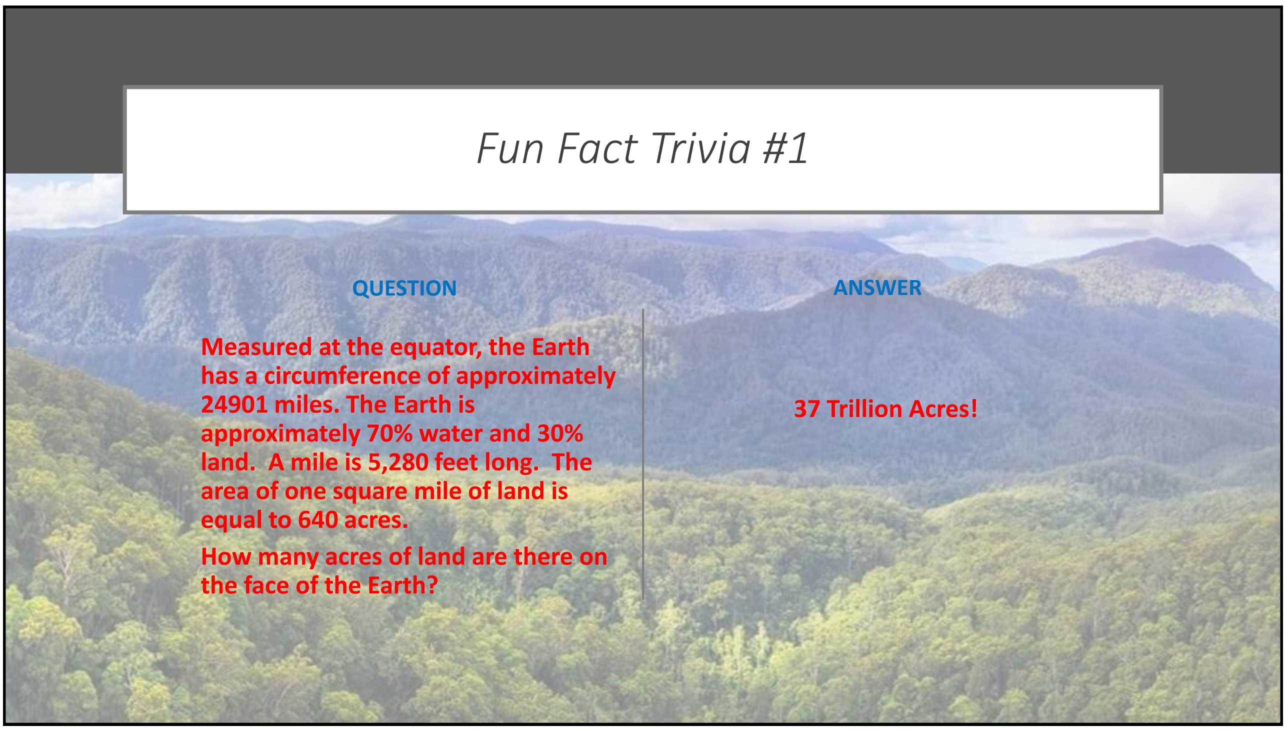
1


Introduction
Presenter 1
Brief bio (credentials & experience)
Brief bio 2 (why you came into the profession)
Presenter 2
Brief bio (credentials & experience)
Brief bio 2 (why you came into the profession)

2


Presentation Overview
What is Land Surveying?
Who is a Land Surveyor?
Clients We Work With
Everyday Projects
Is Land Surveying for You?
Path to Becoming a Surveyor

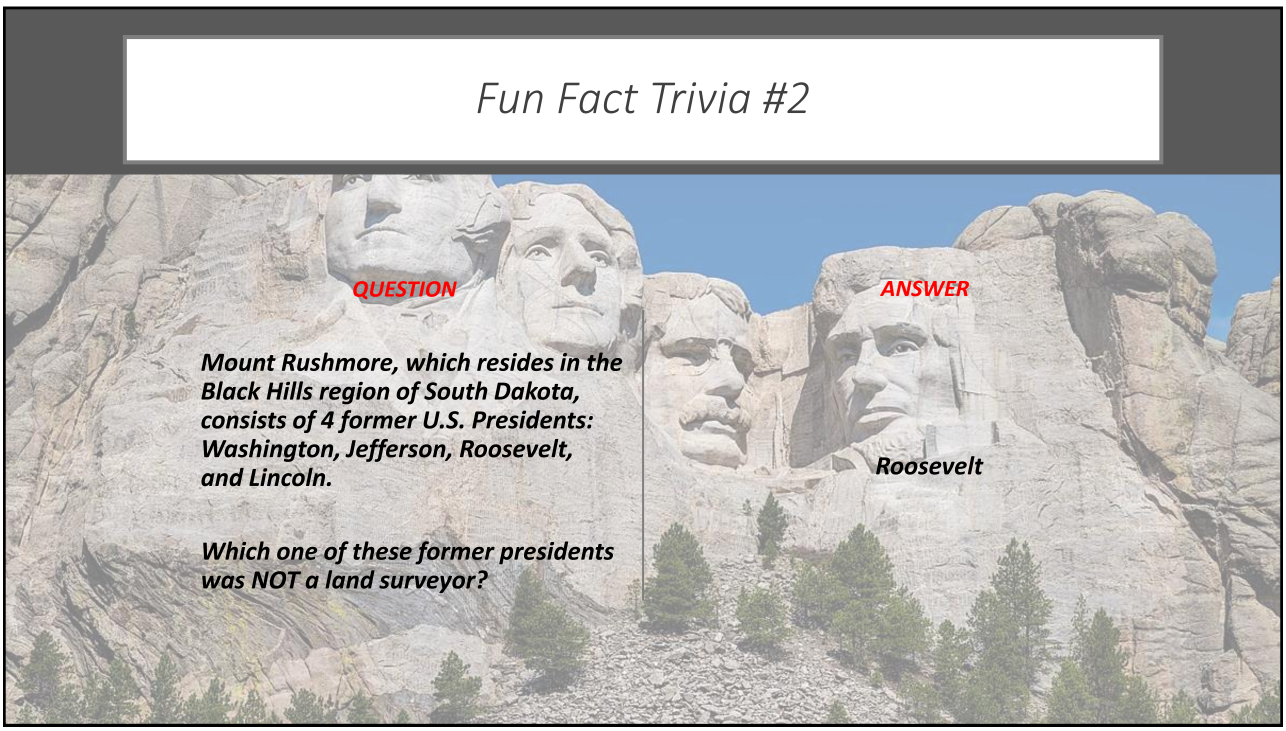
3


Fun Fact Trivia #1
QUESTION
Measured at the equator, the Earth has a circumference of approximately 24901 miles. The Earth is approximately 70% water and 30% land. A mile is 5,280 feet long. The area of one square mile of land is equal to 640 acres.
How many acres of land are there on the face of the Earth?
ANSWER
37 Trillion Acres!

4


What is the Land Surveying Profession?
A profession made up of professionals and non-professionals with varying degrees of education, ranging from Bachelor of Science to high school diploma, responsible for determining property boundaries and encumbrances for all parcels of land and collecting georeferenced spatial data in an organized manner to provide to engineers and architects for design projects.

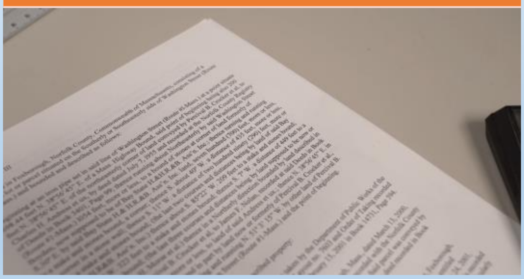
5


Fun Fact Trivia #2
QUESTION
Mount Rushmore, which resides in the Black Hills region of South Dakota, consists of 4 former U.S. Presidents: Washington, Jefferson, Roosevelt, and Lincoln.
Which one of these former presidents was NOT a land surveyor?
ANSWER
Roosevelt

6

Who is a Land Surveyor?

Boundary Experts



Data Acquisition Experts

Who do Surveyors Work With?

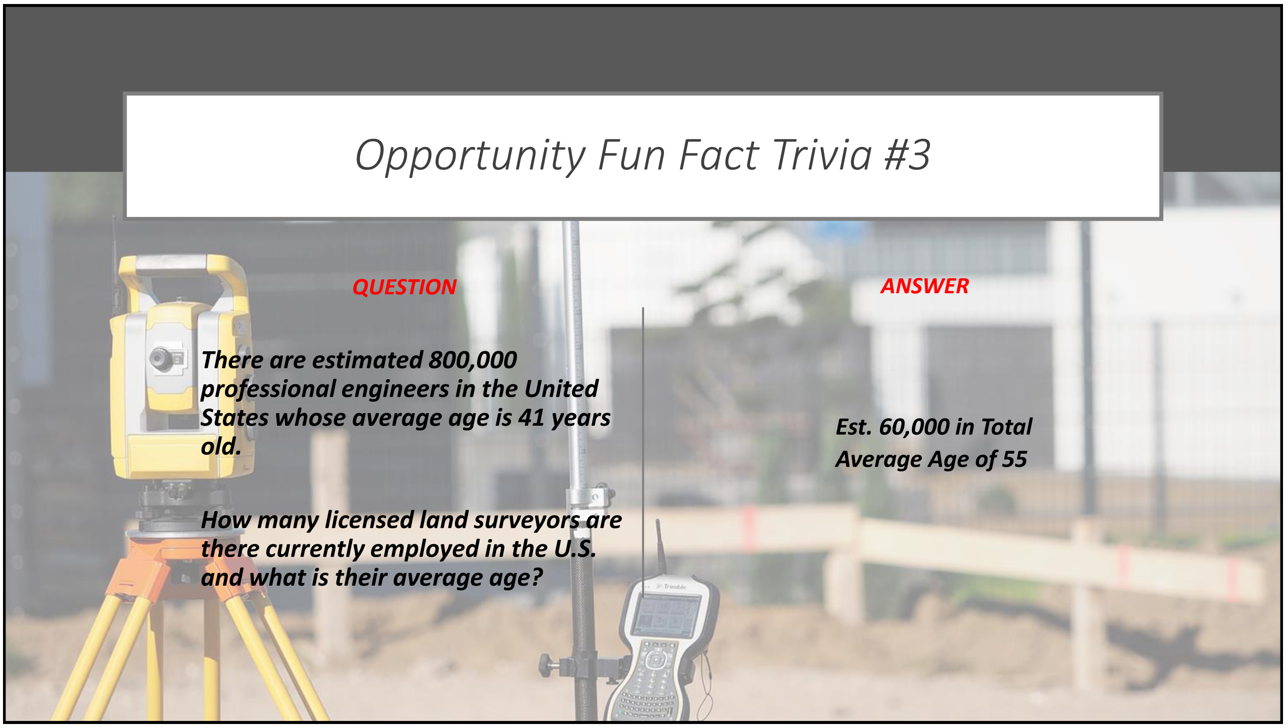
What Types of Surveys do We Perform?

9

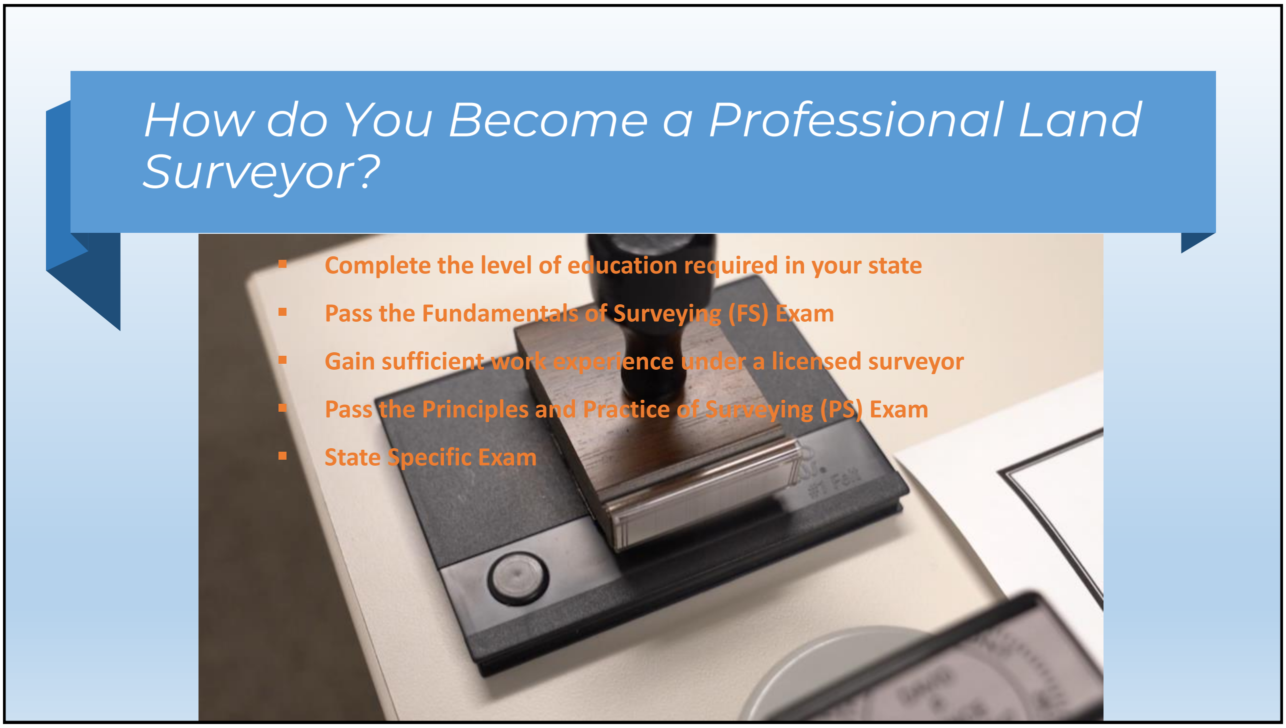
Why Land Surveying is for You!

- Outdoor/Indoor Profession

10


Opportunity Fun Fact Trivia #3
QUESTION
There are estimated 800,000 professional engineers in the United States whose average age is 41 years old.
How many licensed land surveyors are there currently employed in the U.S. and what is their average age?
ANSWER
Est. 60,000 in Total
Average Age of 55

11


How do You Become a Professional Land Surveyor?
Complete the level of education required in your state
Pass the Fundamentals of Surveying (FS) Exam
Gain sufficient work experience under a licensed surveyor
Pass the Principles and Practice of Surveying (PS) Exam
State Specific Exam

12

Thank You!

Questions?

Interested in Learning More on Our Profession...

malsce.org

nhlsa.org

nsps.us.com

13

Augmenting Traditional Underground Utility Locating using Radar Tomography

Michael A. Clifford
Principal in Charge

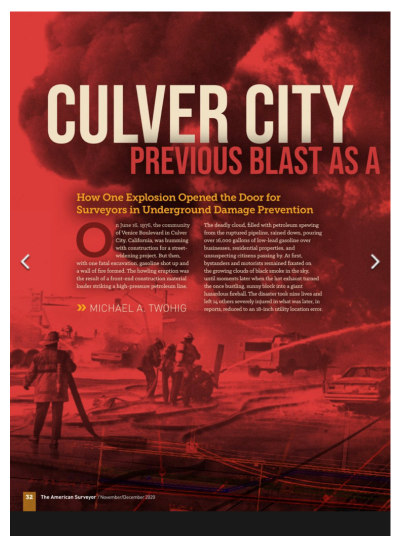
Michael A. Twohig
Project Director for Subsurface Mapping

Mitch Liddell, PhD
Geophysicist and GPR Lead

DGT Associates
Surveying & Engineering

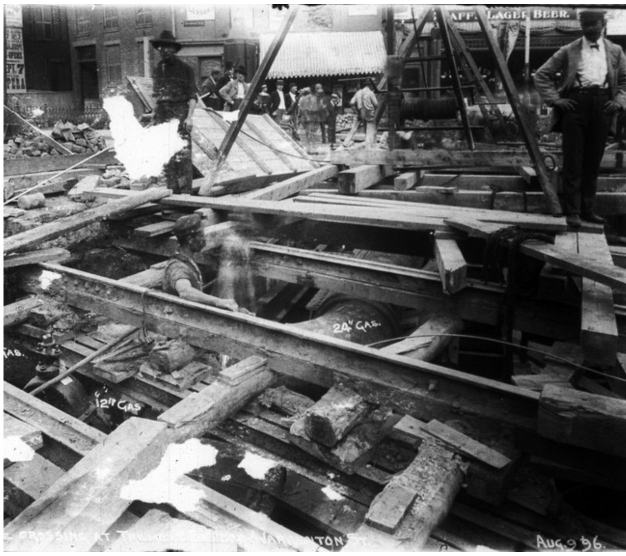
1

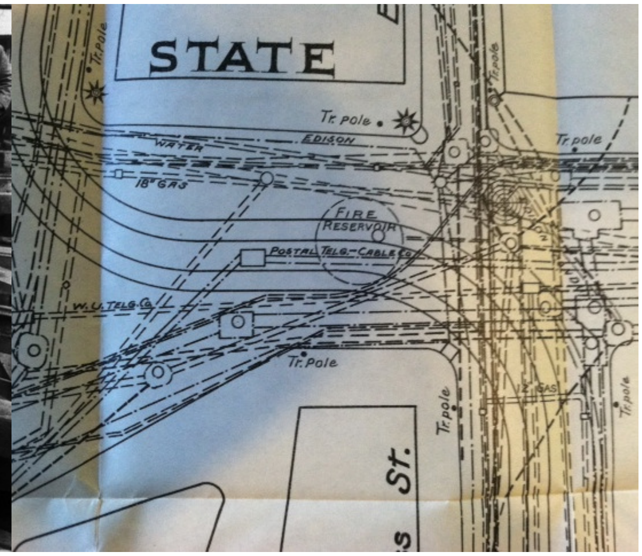
SUM and Underground Damage Prevention programs are closely connected.



2

Old streets in cities and towns do not give up their secrets easily.





3

massDOT
Massachusetts Department of Transportation
Highway Division

Number: E-21-005
Date: 12/21/21

ENGINEERING DIRECTIVE

Carrie Lavallee, P.E. (signature on original)

CHIEF ENGINEER

Subsurface Utility Engineering (SUE)

Effective immediately, all new projects approved by the Project Review Committee (PRC) and anticipated to involve subsurface utility relocations shall include scope and workhour provisions for the completion of Subsurface Utility Engineering (SUE) Level B during the project design phase. This requirement applies to all new projects, regardless of whether MassDOT, a municipality or another entity is responsible for funding the design.

Once the design commences, the District Utility and Constructability Engineer (DUCE) will determine whether SUE Level B is required upon their initial review of the project. Preferably, all required SUE Level B work will be performed at the pre-25% or 25% design stage.

The Designer is responsible for performing the required services or for hiring a qualified subconsultant to perform the required services. The work shall only be performed by qualified firms. The MassDOT Architects and Engineers Review Board maintains a list of prequalified SUE firms, which is publicly available on mass.gov (https://www.mass.gov/prequalification-of-architectural-engineering-firms).

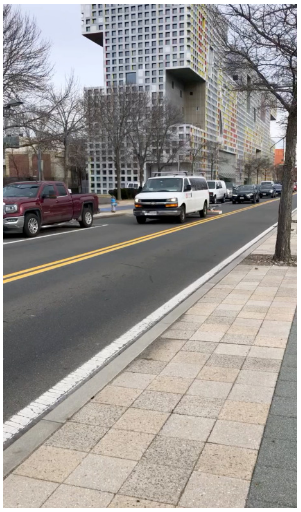
For active designs and other projects approved by the PRC prior to issuance of this directive, MassDOT recommends the use of appropriate Subsurface Utility Engineering services where subsurface utility relocations are required.

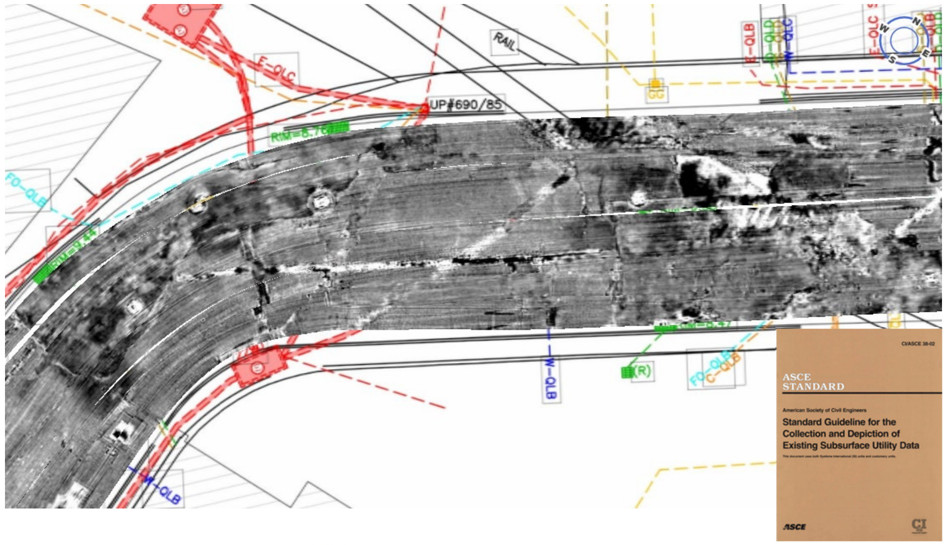
All new projects…shall include scope and workhour provision for completion of SUE Level B

How can we best respond?

4

Radar Tomography. Using wide array Ground Penetrating Radar (GPR). ASCE 38-02 Quality Level B





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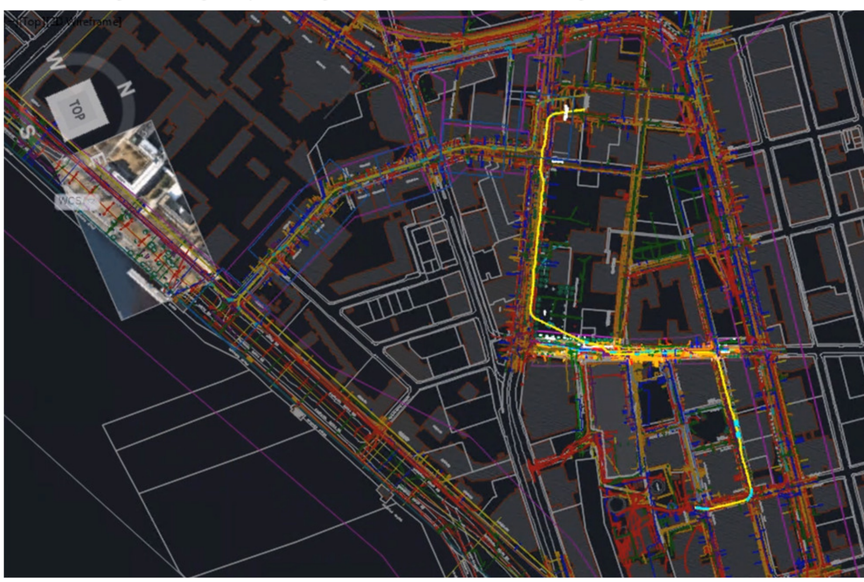
5

Resolving ambiguity using Ground Penetrating Radar (GPR). ASCE 38-02 Quality Level B



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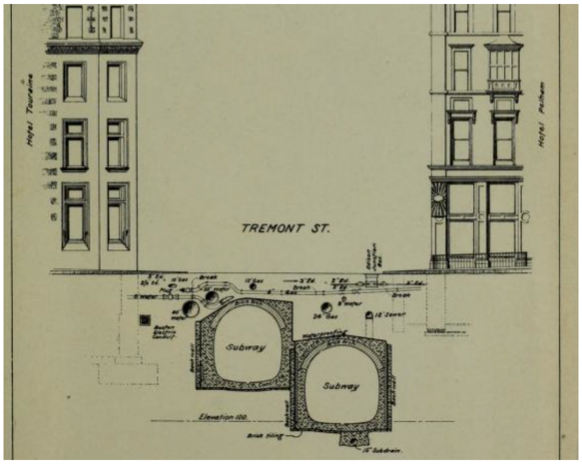
6

A short history of underground utilities



DGT Associates
Surveying &
Engineering

7

Ancient civilizations have been burying utilities for thousands of years.

This picture is a 2000-year-old wooden pipe in an old Roman garrison in the United Kingdom.

A 3000-year-old clay pipe in an ancient Greek site

Photos Courtesy of James Dunn.

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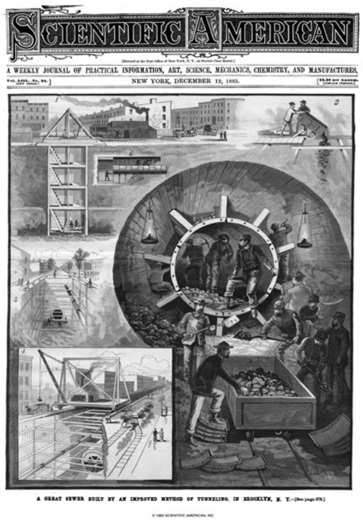
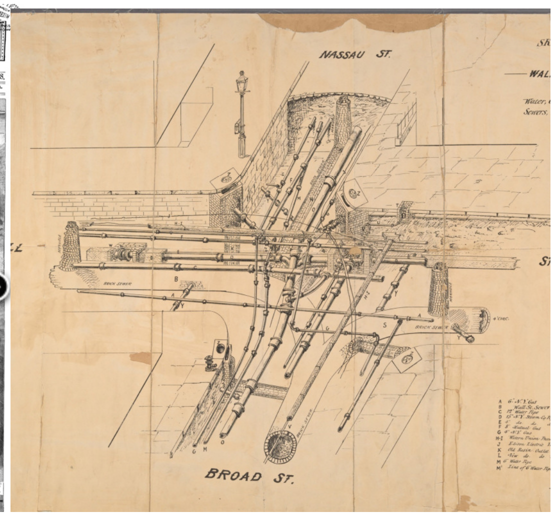
8

In the late 1800's there was an infrastructure boon across the globe.

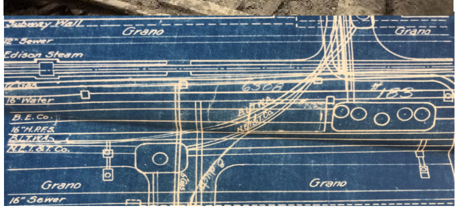


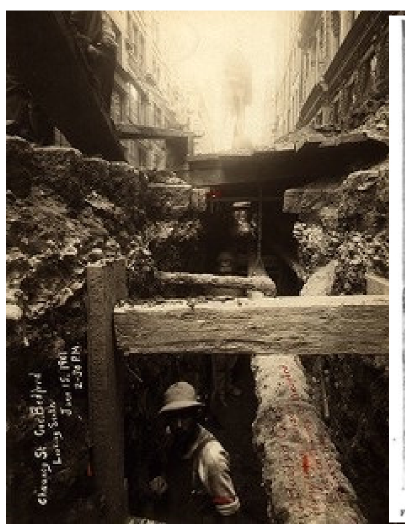


Courtesy Of New York Public Library

9

1840 – The asset owners began constructing extensive underground infrastructure networks.





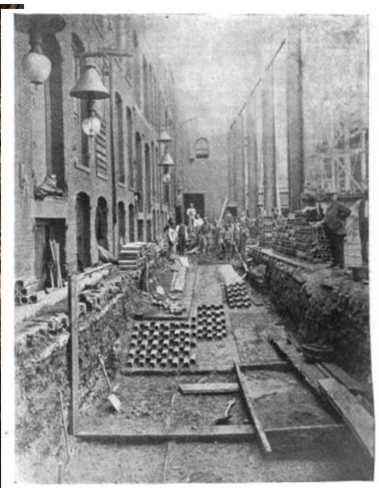
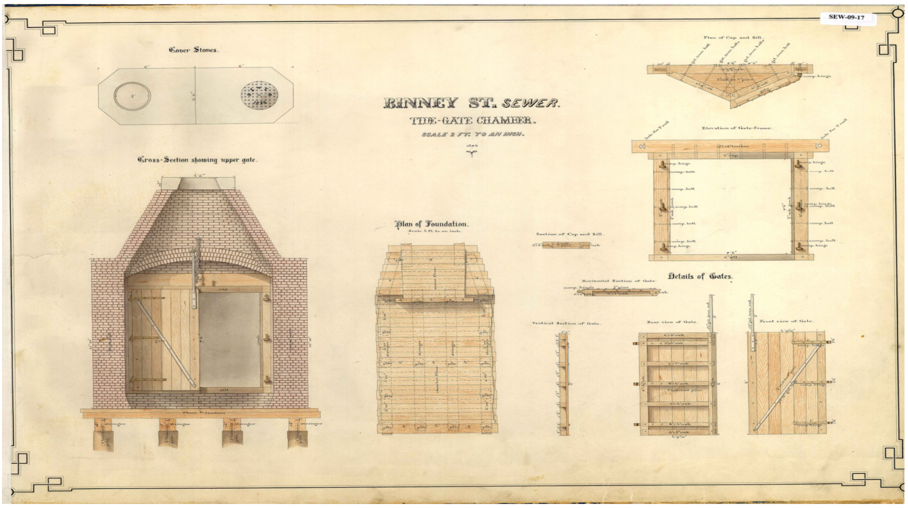


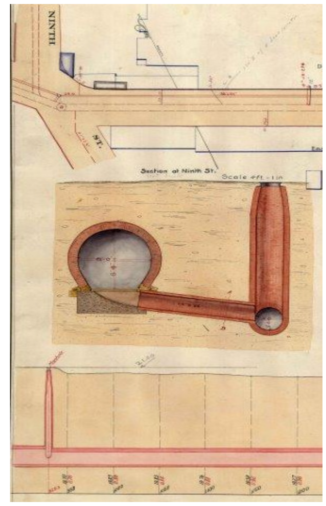
FIG. 53.—CONDUIT IN ALLEY LEADING TO THIRD DISTRICT STATION, AT-

Courtesy Of Digital Commonwealth

10

1870s – Historic Utility Plans, Cambridge, MA.

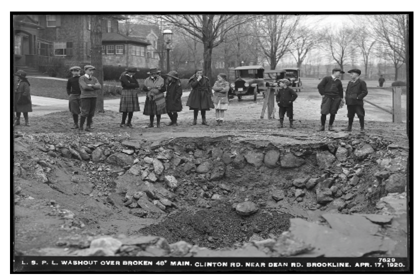


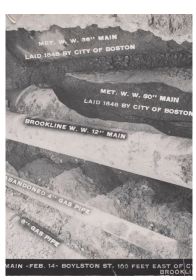


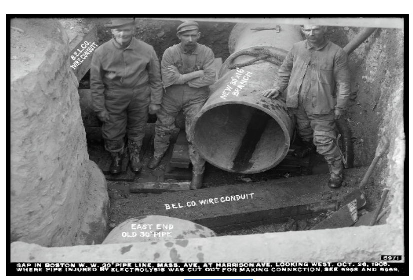
Courtesy of the City Of Cambridge GIS collection

11

1890 – The asset owners of the day struggled with aging infrastructure.







1890

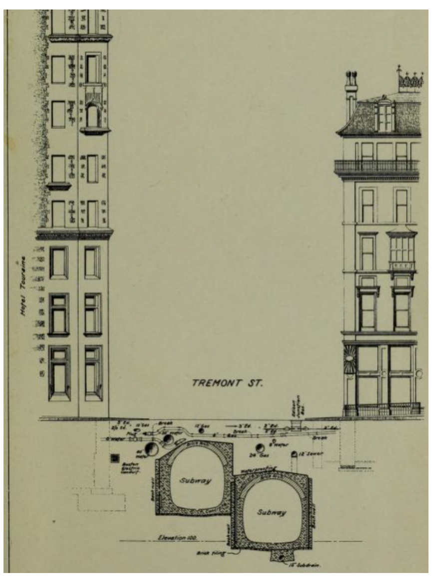
12

Lessons from Boston's Underground

DGT Associates Surveying & Engineering

13

Building major infrastructure networks throughout the US in the late 1890's



SECTION 7.-- SCOLLAY SQUARE, LOOKING NORTH. CONSTRUCTING SIDEWALLS. JULY 15, 1897.

Courtesy of Boston Transit Commission Annual Records

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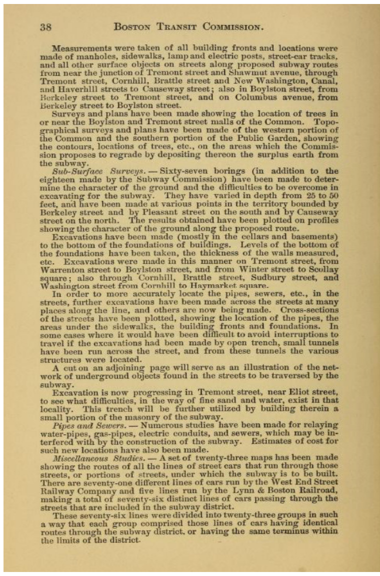
14

Documentation, Reporting, and Dissemination of existing condition surveys



38 BOSTON TRANSIT COMMISSION.

Measurements were taken of all building fronts and locations were made of manholes, sidewalks, lamp and electric posts, street-car tracks, and all other surface objects on streets along proposed subway routes from near the junction of Tremont street and Shawmut avenue, through Tremont street, Cornhill, Brattle street and New Washington, Canal, and Haverhill streets to Causeway street; also in Boylston street, from Berkeley street to Tremont street, and on Columbus avenue, from Berkeley street to Boylston street.

Surveys and plans have been made showing the location of trees in or near the Boylston and Tremont street malls of the Common. Topographical surveys and plans have been made of the western portion of the Common and the southern portion of the Public Garden, showing the contours, locations of trees, etc., on the areas which the Commission proposes to regrade by depositing thereon the surplus earth from the subway.

Sub-Surface Surveys. — Sixty-seven borings (in addition to the eighteen made by the Subway Commission) have been made to determine the character of the ground and the difficulties to be overcome in excavating for the subway. They have varied in depth from 25 to 50 feet, and have been made at various points in the territory bounded by Berkeley street and by Pleasant street on the south and by Causeway street on the north. The results obtained have been plotted on profiles showing the character of the ground along the proposed route.

Excavations have been made (mostly in the cellars and basements) to the bottom of the foundations of buildings. Levels of the bottom of the foundations have been taken, the thickness of the walls measured, etc. Excavations were made in this manner on Tremont street, from Warrenton street to Boylston street, and from Winter street to Scollay square; also through Cornhill, Brattle street, Sudbury street, and Washington street from Cornhill to Haymarket square.

In order to more accurately locate the pipes, sewers, etc., in the streets, further excavations have been made across the streets at many places along the line, and others are now being made. Cross-sections of the streets have been plotted, showing the location of the pipes, the areas under the sidewalks, the building fronts and foundations. In some cases where it would have been difficult to avoid interruptions to travel if the excavations had been made by open trench, small tunnels have been run across the street, and from these tunnels the various structures were located.

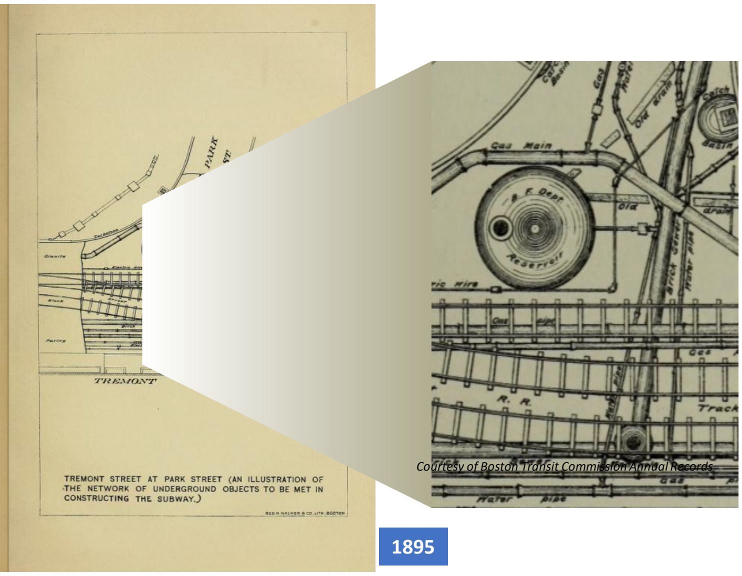
A cut on an adjoining page will serve as an illustration of the network of underground objects found in the streets to be traversed by the subway.

Excavation is now progressing in Tremont street, near Eliot street, to see what difficulties, in the way of fine sand and water, exist in that locality. This trench will be further utilized by building therein a small portion of the masonry of the subway.

Pipes and Sewers. — Numerous studies have been made for relaying water-pipes, gas-pipes, electric conduits, and sewers, which may be interfered with by the construction of the subway. Estimates of cost for such new locations have also been made.

Miscellaneous Studies. — A set of twenty-three maps has been made showing the routes of all the lines of street cars that run through those streets, or portions of streets, under which the subway is to be built. There are seventy-one different lines of cars run by the West End Street Railway Company and five lines run by the Lynn & Boston Railroad, making a total of seventy-six distinct lines of cars passing through the streets that are included in the subway district.

These seventy-six lines were divided into twenty-three groups in such a way that each group comprised those lines of cars having identical routes through the subway district, or having the same terminus within the limits of the district.

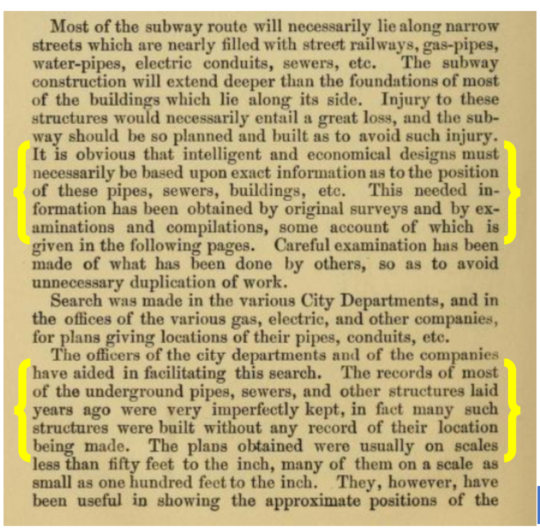


Courtesy of Boston Transit Commission Annual Records

1895

MASCE

Reports documented the project's approach and the site surveys work required to prepare the contract plans**.**

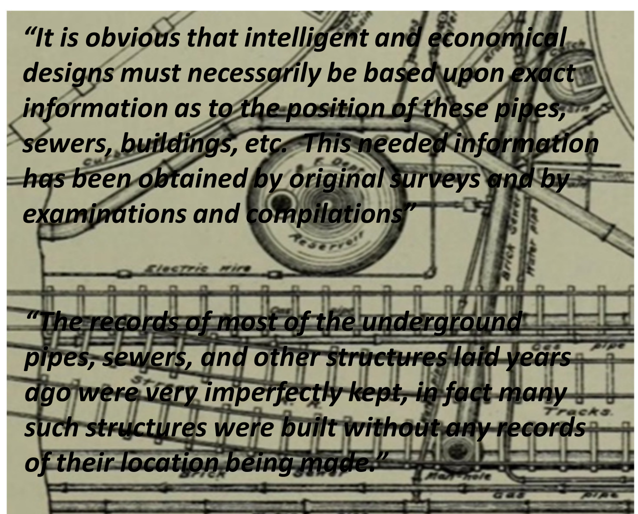


Most of the subway route will necessarily lie along narrow streets which are nearly filled with street railways, gas-pipes, water-pipes, electric conduits, sewers, etc. The subway construction will extend deeper than the foundations of most of the buildings which lie along its side. Injury to these structures would necessarily entail a great loss, and the subway should be so planned and built as to avoid such injury. It is obvious that intelligent and economical designs must necessarily be based upon exact information as to the position of these pipes, sewers, buildings, etc. This needed information has been obtained by original surveys and by examinations and compilations, some account of which is given in the following pages. Careful examination has been made of what has been done by others, so as to avoid unnecessary duplication of work.

Search was made in the various City Departments, and in the offices of the various gas, electric, and other companies, for plans giving locations of their pipes, conduits, etc.

The officers of the city departments and of the companies have aided in facilitating this search. The records of most of the underground pipes, sewers, and other structures laid years ago were very imperfectly kept, in fact many such structures were built without any record of their location being made. The plans obtained were usually on scales less than fifty feet to the inch, many of them on a scale as small as one hundred feet to the inch. They, however, have been useful in showing the approximate positions of the

1895



Courtesy of the Boston Transit Commission Report 1895)

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Late-1800s Subsurface Investigations for Design and Construction Projects

Courtesy of Boston Transit Commission Annual Records

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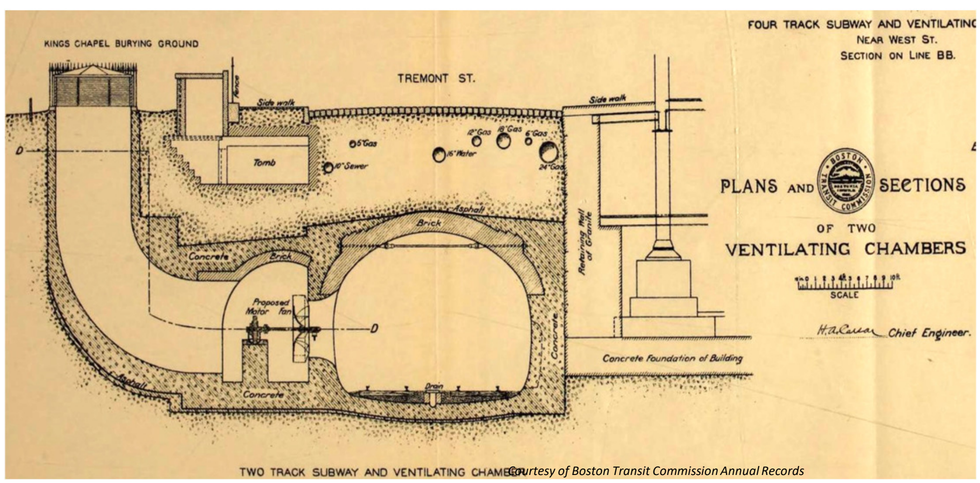
17

1894 – Utility Locating and Mapping for Proposed Subway Project. Existing Conditions Survey.



Courtesy of Boston Transit Commission Annual Records

1894

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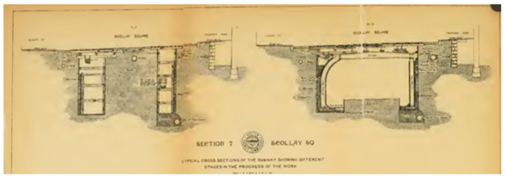
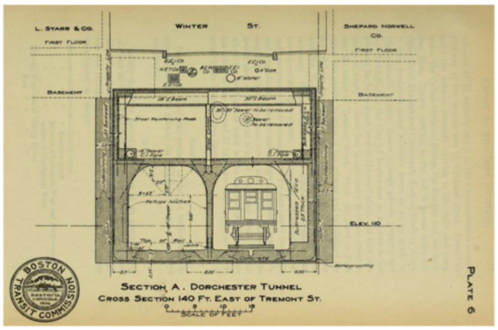
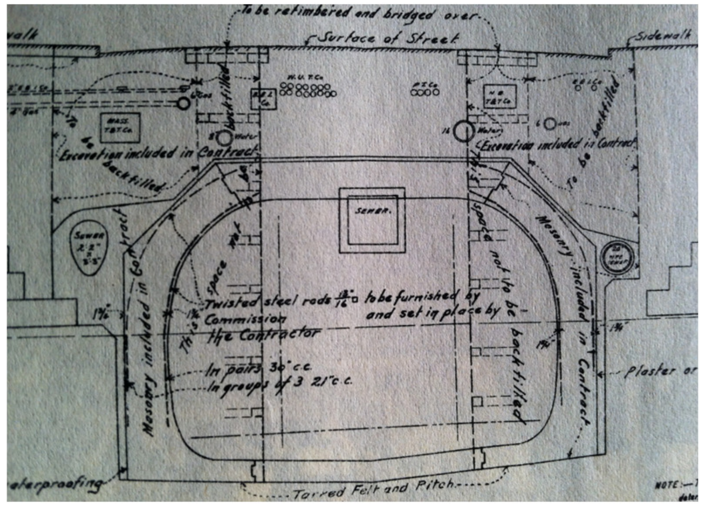
18

1897 – Boston Subway System Plans.

1897 Subsurface Information Modeling (SIM)?







1897

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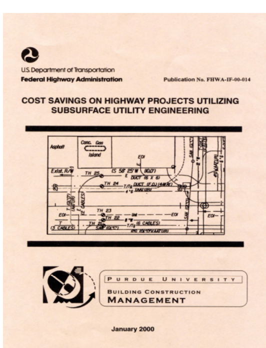
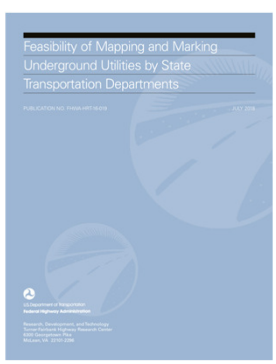
19

Subsurface Utility Locating and Mapping awareness





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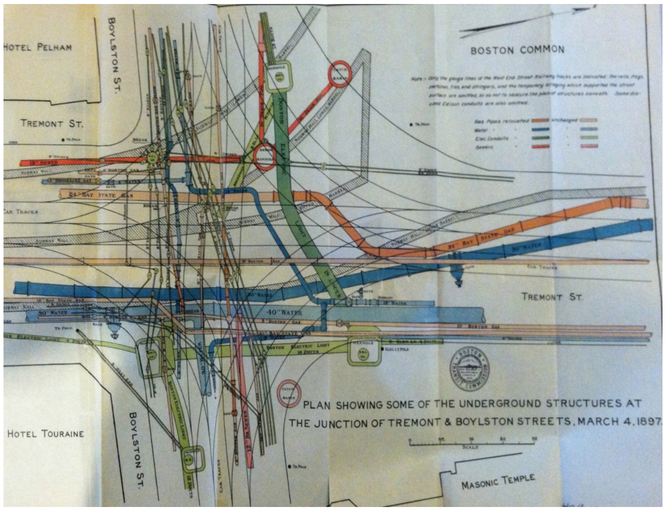
20

1897 – Boston Subway System Plans. A hard lesson on Underground Damage Prevention



SIX FILLED, OTHERS MAY DIE.
Boston; Mar 5, 1897; ProQuest Historical Newspapers Boston Globe (1872 - 1927)
pg. 1

SIX KILLED, OTHERS MAY DIE.

Explosion of Gas at Tremont and Boylston Sts Followed by Flames.

Scores Were Injured by Flying and Falling Glass and in The Demolished Cars.

VIEW OF SCENE OF EXPLOSION DURING BURNING OF CARS—FROM A PHOTOGRAPH.

Spark from an Electric Car Ignited Gas Confined Under Street Planking and Caused a Shock That Knocked People Down and Shattered Window Panes for Blocks—Mayor Quincy Says That the Responsibility Rests Between the Gaslight Company and the Subway Contractors—Inquest Will Be Begun Today—Stories of the Fatality Told by Eyewitnesses.

LIST OF THE DEAD.

Rev W. A. START, 60 years, bursar at Tufts college, killed while standing on the sidewalk in front of hotel Pelham.

GILFORD D. BIGELOW, 64 years, 233 Northampton st, conductor of Back Bay car, killed instantly.

WILLIAM L. VINAL, 40 years, private secretary to Thomas W. Lawson, 33 State st, home in Salem; killed in coupe which was destroyed by the explosion.

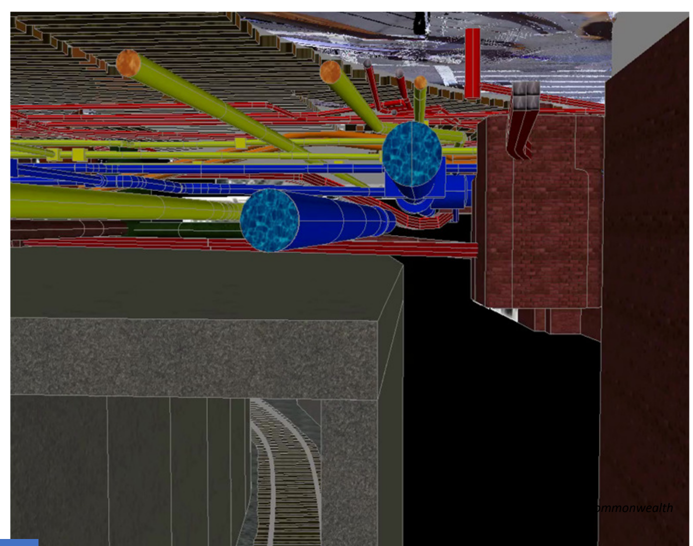
BENJAMIN DOWNING, 35 years, driver of the public carriage in which Vinal rode.

CITY HOSPITAL.

Continued on the Third Page.

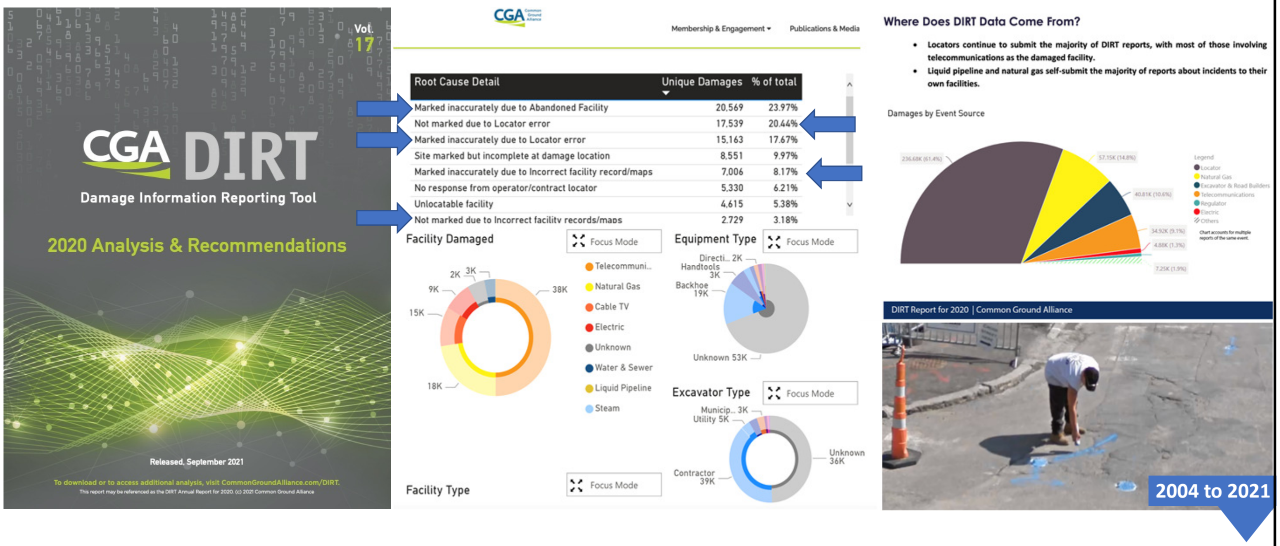
21

A Historical Perspective of Subsurface Utility Mapping (SUM)



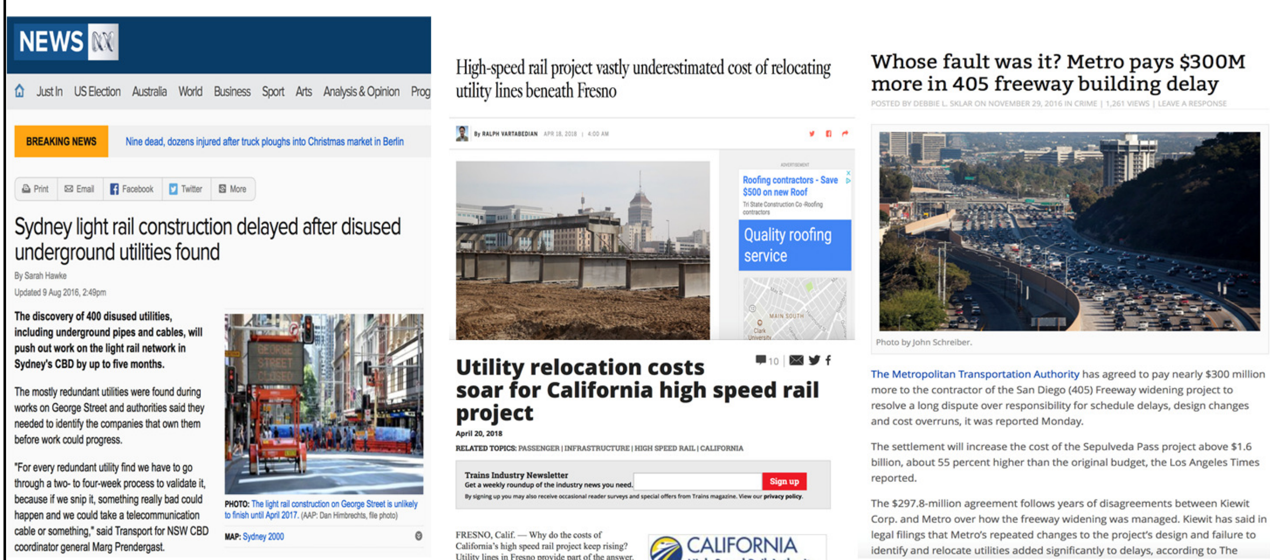
22

US. The Common Ground Alliance (CGA) Dirt report for tracking damage to underground assets.



23

What is the cost of errors and omissions when mapping underground utilities?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BREAKING NEWS Nine dead, dozens injured after truck ploughs into Christmas market in Berlin

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Sydney light rail construction delayed after disused underground utilities found

By Sarah Hawke

Updated 9 Aug 2016, 2:49pm

The discovery of 400 disused utilities, including underground pipes and cables, will push out work on the light rail network in Sydney's CBD by up to five months.

The mostly redundant utilities were found during works on George Street and authorities said they needed to identify the companies that own them before work could progress.

"For every redundant utility find we have to go through a two- to four-week process to validate it, because if we snip it, something really bad could happen and we could take a telecommunication cable or something," said Transport for NSW CBD coordinator general Marg Prendergast.

PHOTO: The light rail construction on George Street is unlikely to finish until April 2017. (AAP: Dan Himbrechts, file photo)

MAP: Sydney 2000

High-speed rail project vastly underestimated cost of relocating utility lines beneath Fresno

By RALPH VARTABEDIAN APR 18, 2018 | 4:00 AM

Utility relocation costs soar for California high speed rail project

April 20, 2018

RELATED TOPICS: PASSENGER | INFRASTRUCTURE | HIGH SPEED RAIL | CALIFORNIA

FRESNO, Calif. — Why do the costs of California's high speed rail project keep rising? Utility lines in Fresno provide part of the answer.

CALIFORNIA High-Speed Rail Authority

Whose fault was it? Metro pays $300M more in 405 freeway building delay

POSTED BY DEBBIE L. SKLAR ON NOVEMBER 29, 2016 IN CRIME | 1,261 VIEWS | LEAVE A RESPONSE

Photo by John Schreiber.

The Metropolitan Transportation Authority has agreed to pay nearly $300 million more to the contractor of the San Diego (405) Freeway widening project to resolve a long dispute over responsibility for schedule delays, design changes and cost overruns, it was reported Monday.

The settlement will increase the cost of the Sepulveda Pass project above $1.6 billion, about 55 percent higher than the original budget, the Los Angeles Times reported.

The $297.8-million agreement follows years of disagreements between Kiewit Corp. and Metro over how the freeway widening was managed. Kiewit has said in legal filings that Metro's repeated changes to the project's design and failure to identify and relocate utilities added significantly to delays, according to The

24

Not everyone takes utility locating and mapping as seriously as we do.

Source KTVU San Francisco

MALSCE Commercially Confidential / Michael A Twohig / DGT Associates

25

Not everyone takes utility locating and mapping as seriously as we do.

2009

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26

A risks associated with underground utilities. Environmental and Geotechnical Borings

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27

Some designers do not approach Subsurface Utility Mapping with the appropriate respect.

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Commercially Confidential / Michael A Twohig / DGT Associates

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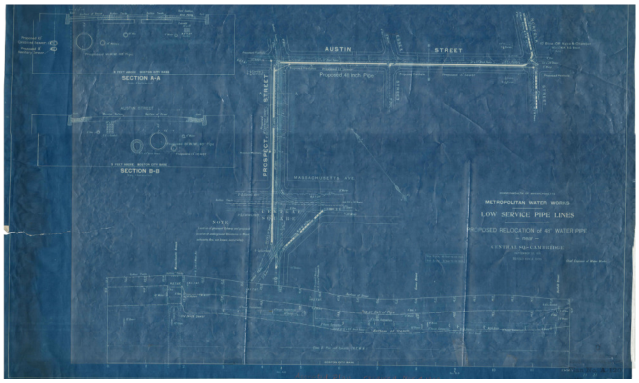
Subsurface Utility Plans



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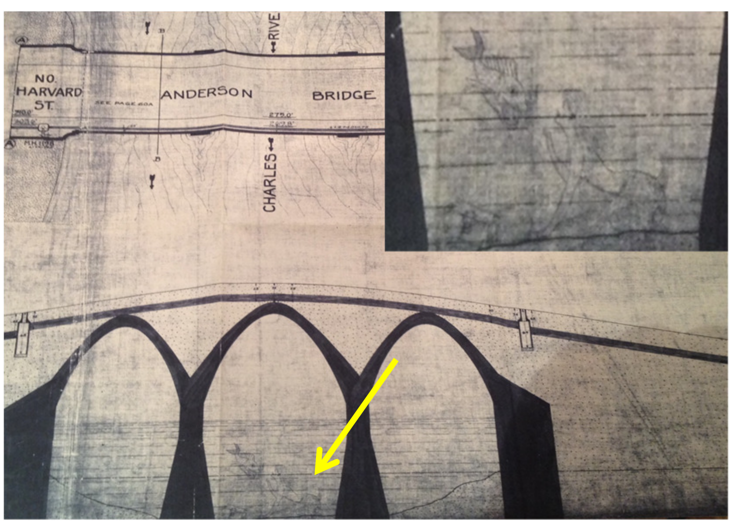
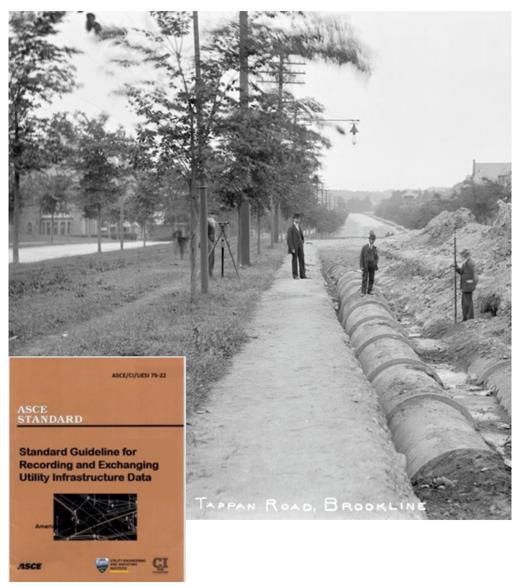
Why legacy utility is important for SUM professionals. Hidden gems and humorous animations.





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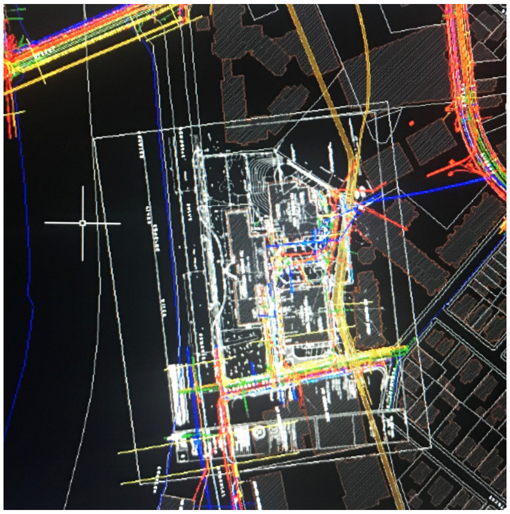
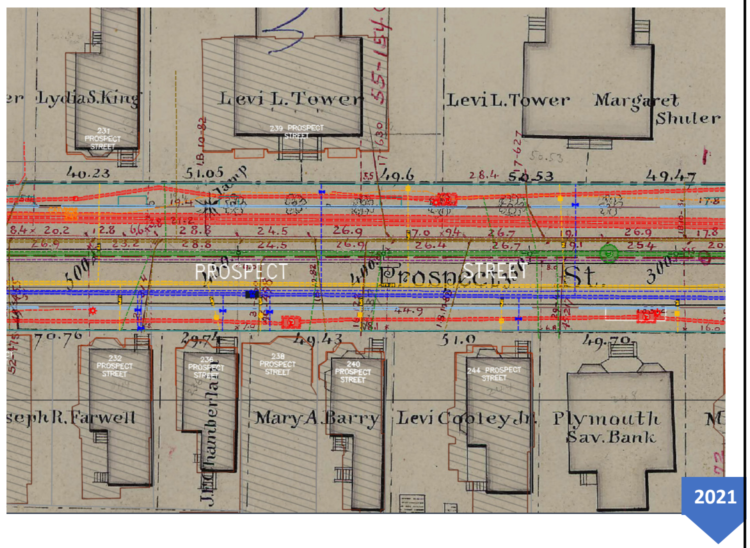
The Utility data for public and private asset owners is very important to QA/QC utility mapping





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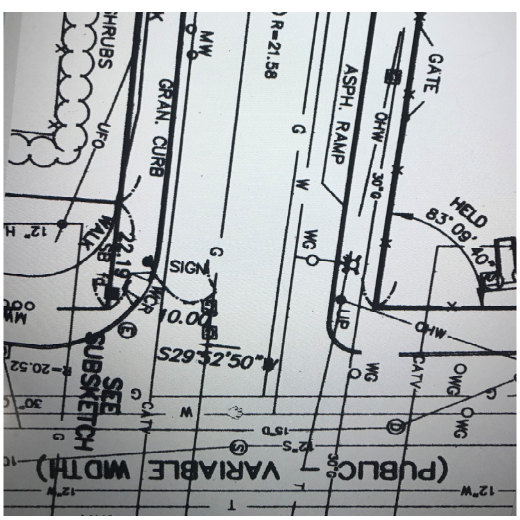
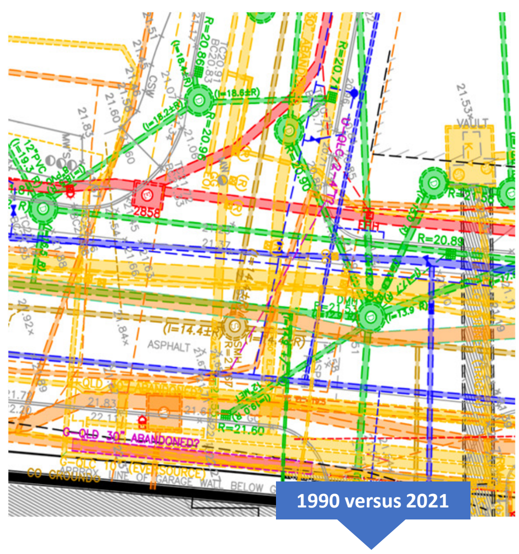
This is the difference between a typical utility compilation from a Surveyor compared to a SUM plan





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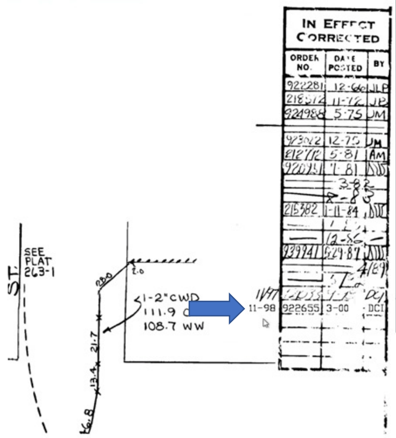
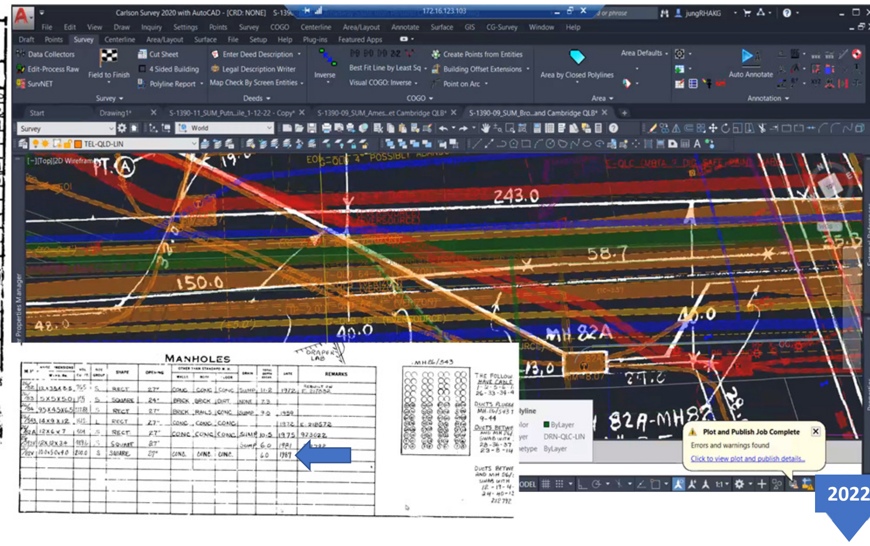
32

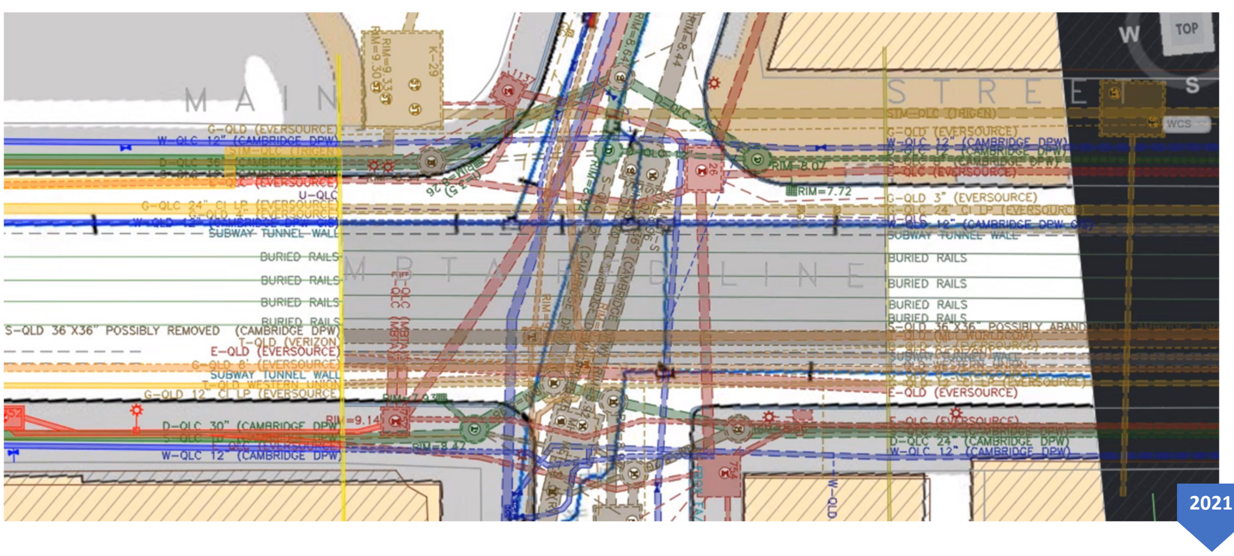
Todays Challenge. Major telecommunication firms had schematic records.
They stopped updating these documents 20 years ago while other telecoms provide no records for mapping.



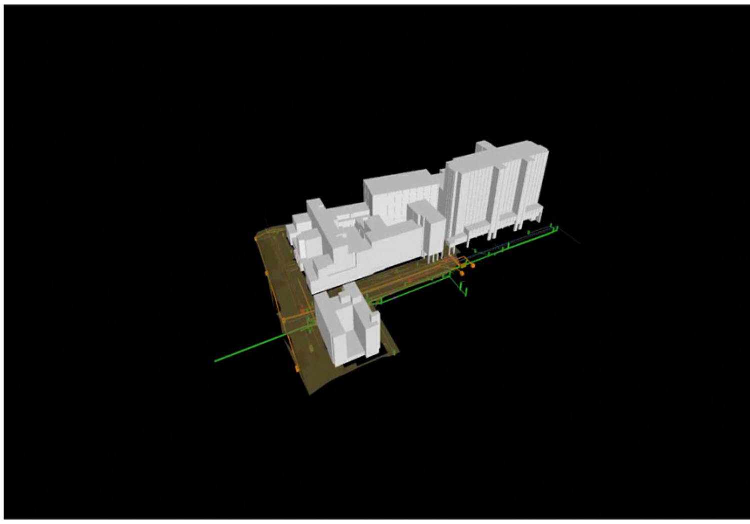


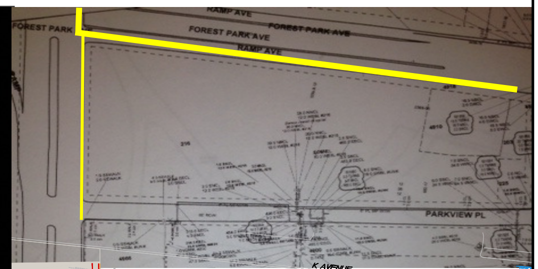
The asset owners current documents.
The last update was 1998.

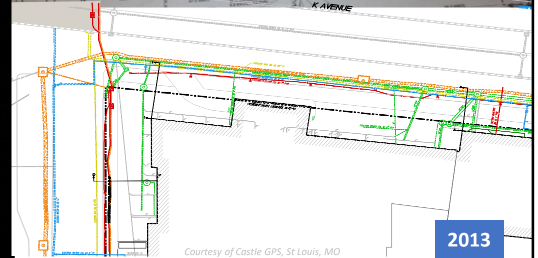
Using an asset owners GIS inside a SUM plan. Several notable accuracy differences appear.



Mitigating Errors and Omissions in Subsurface Utility Mapping Projects



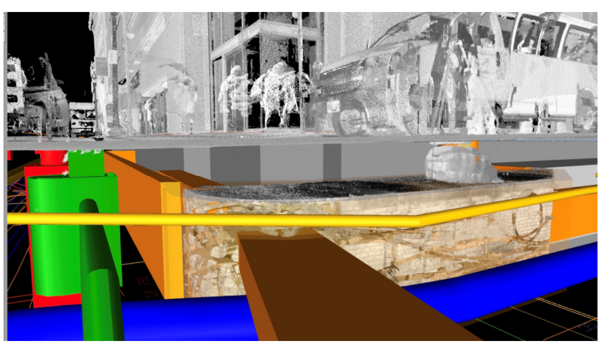




2013

35

Subsurface Utility Mapping



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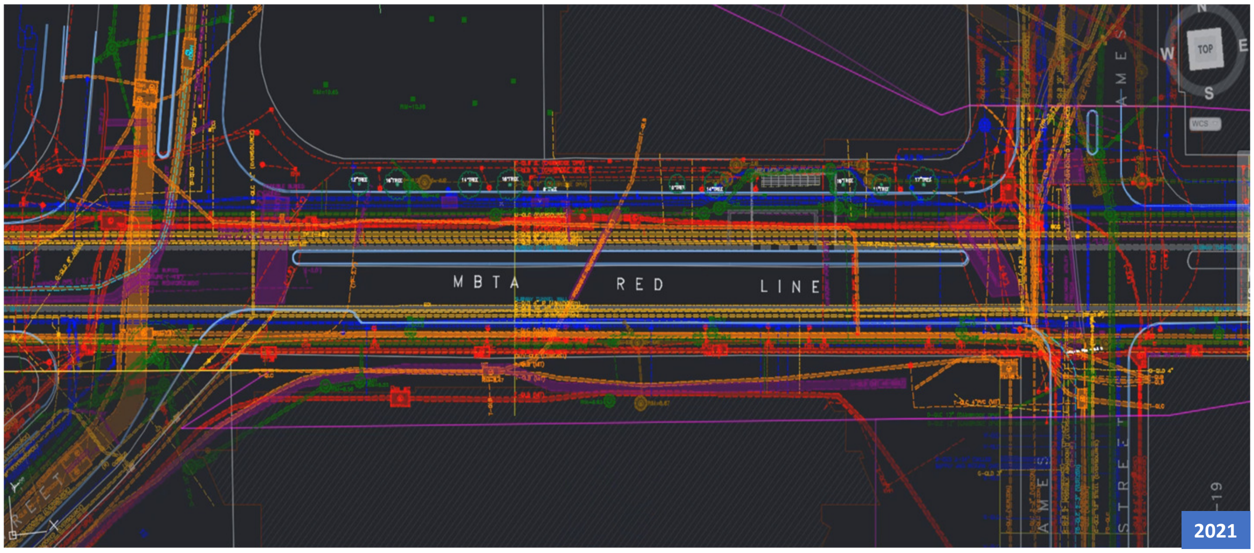
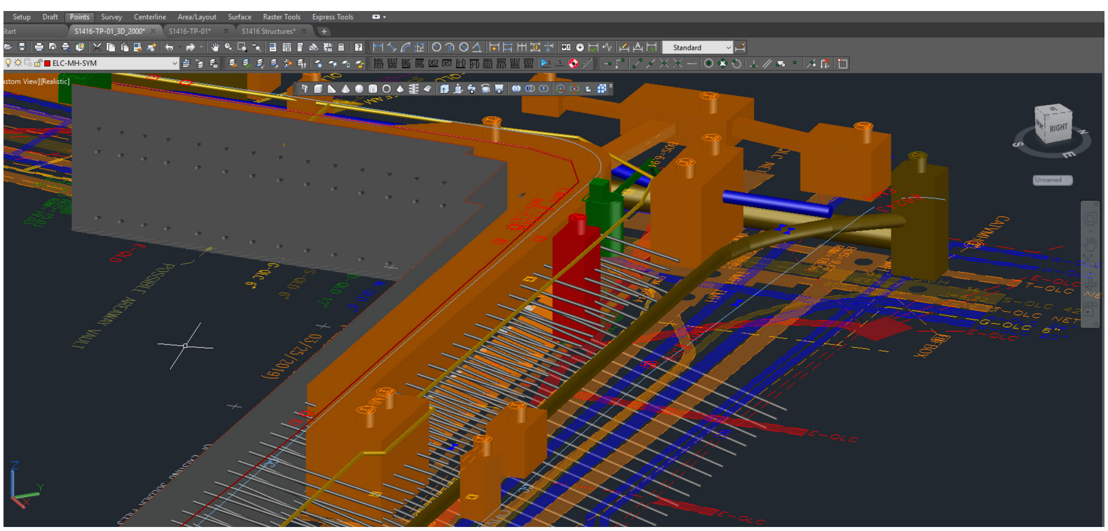
SUM uncovering 150 years of history. A comprehensive SUM program to design and build a line.



2021

37

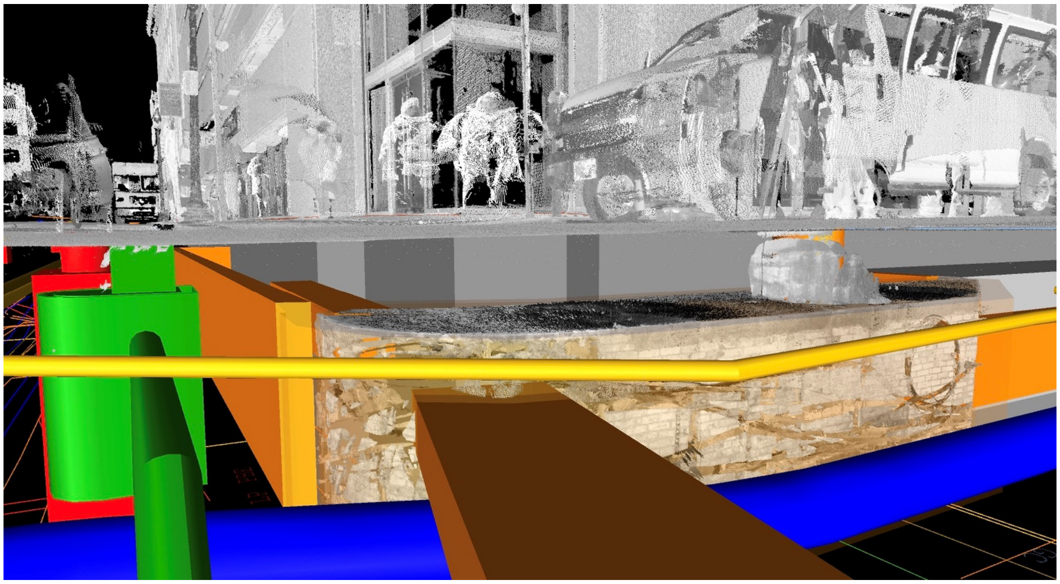
Subsurface Information Modeling (SIM).



2019

38

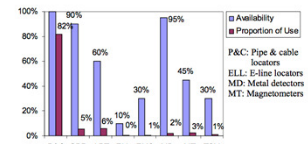
Subsurface Information Modeling (SIM).

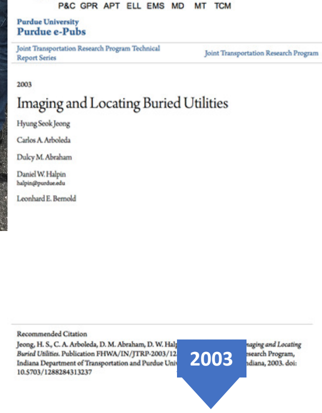


EMI and GPR Locating Systems. The most frequently used devices for utility locating.

Hand-Held Electromagnetic Devices

Push-Cart Ground Penetrating Radar Systems are designed to detect the location of buried facilities and structures.





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Joint Transportation Research Program Technical Report Series — Joint Transportation Research Program

2003

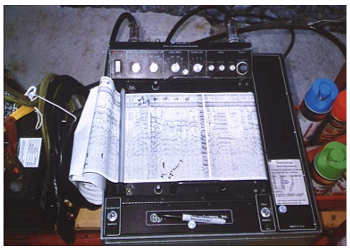
Imaging and Locating Buried Utilities

Hyung Seok Jeong
Carlos A. Arboleda
Dulcy M. Abraham
Daniel W. Halpin
halpin@purdue.edu
Leonhard E. Bernold

Recommended Citation
Jeong, H. S., C. A. Arboleda, D. M. Abraham, D. W. Hal[...] *[...]aging and Locating Buried Utilities.* Publication FHWA/IN/JTRP-2003/12[...] [...]esearch Program, Indiana Department of Transportation and Purdue Uni[...] [...]ndiana, 2003. doi: 10.5703/1288284313237

2003

Ground Penetrating Radar (GPR). Many customers ask for GPR surveys



1993

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41

Most people think of utility locating they think of hand-held **EMI devices.**

2014

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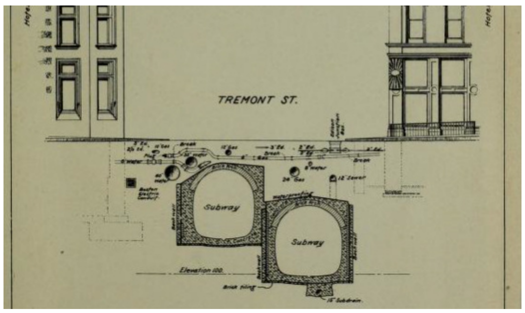
42

The Evolution of Mobile mapping Platforms



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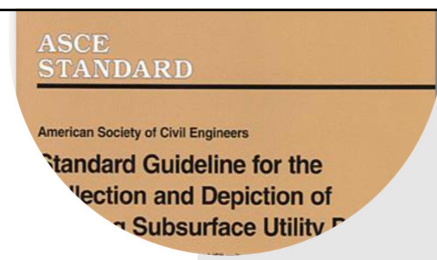

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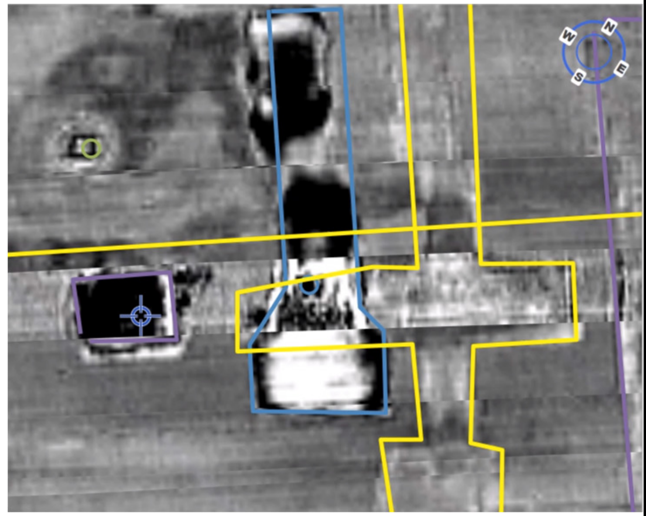
Between 2006 and 2009 33% of construction workers were killed by cars, vans and tractor-trailers.

44

Mobile Mapping with help find anomalies, tanks, vaults and unidentified structures, rails, geology, and "surprise discoveries"



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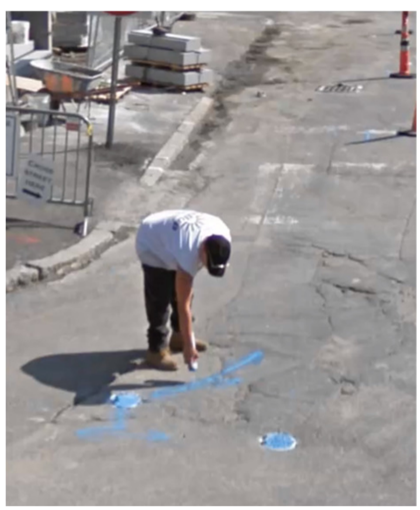
Marking utilities can be very dangerous for utility company personnel and contract locators.



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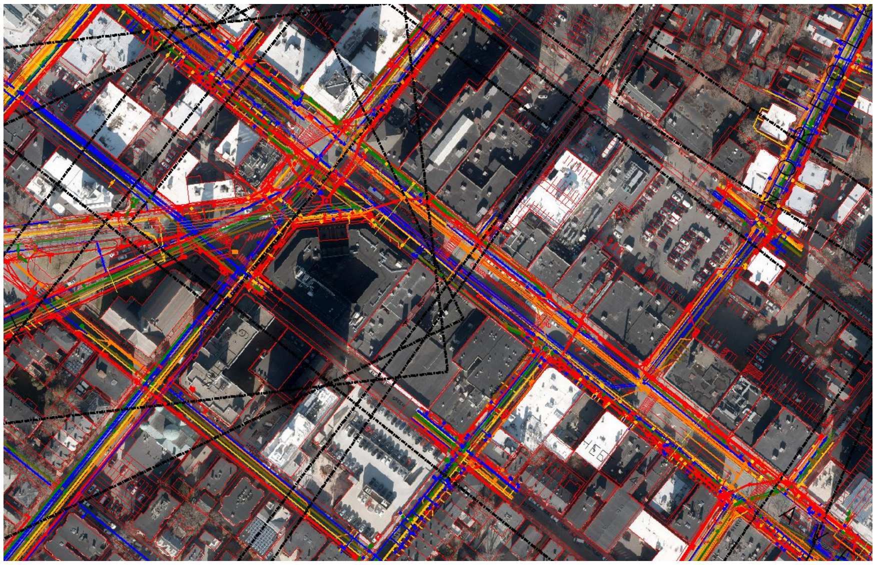
Subsurface Utility Mapping – The Solution to Managing Risk Associated with Underground Work



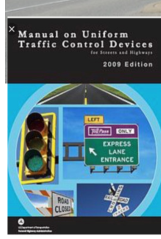
- **"The existence of a low-cost, easy, and quick-to-use surface geophysical tool that identifies all utilities during a planned-route field survey at any site regardless of soil conditions would remove most barriers to effectively managing utility issues in transportation projects. Unfortunately, such a technology does not exist."**
  - **– Dr. Ray Sterling**

Sharp 2 Federally Funded Transportation Research Board, Strategic Highway Research Program, Report S2-R01-RW

47

Why is there a need for Mobile Mapping Platforms?

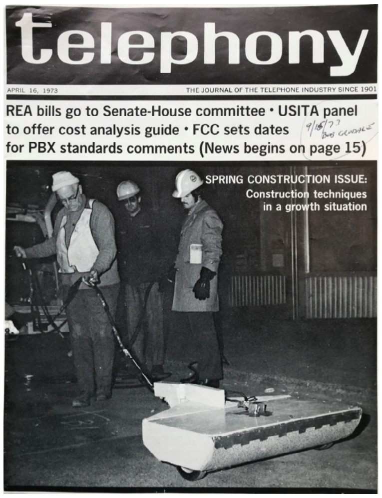
The benefit of a mobile system is the ability to cover large areas in streets, busy roadways and highways without exposing workers to unnecessary traffic risks

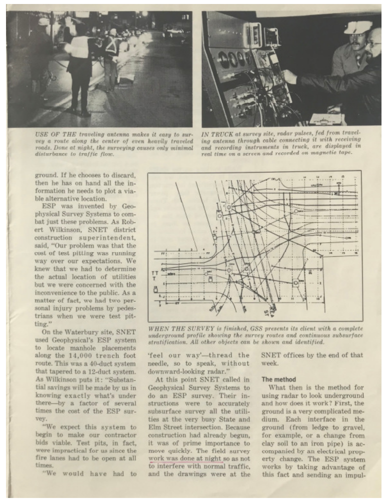


Hand-held and push systems are best suited to the safety of sidewalk area.

48

1973 – Subsurface Utility Mapping | GSSI GPR wide arrays





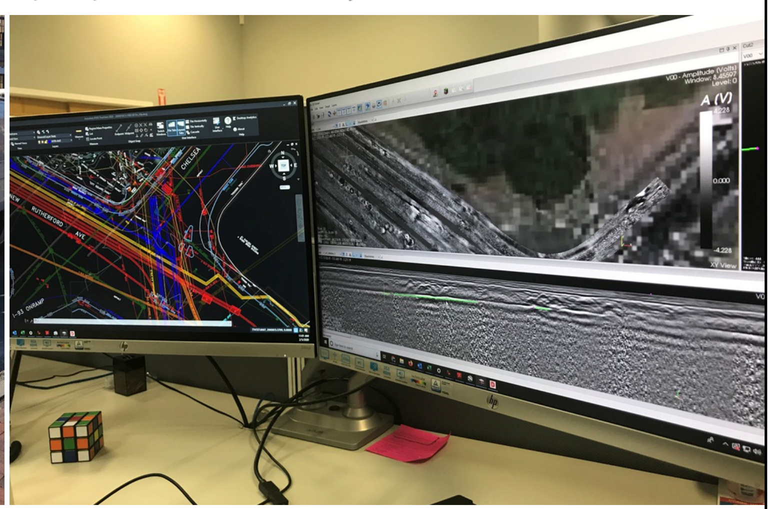
THE NEED FOR telcos to "look underground without going underground" has been accepted for years. From a completely theoretical basis, it would make little sense to test pit or trench if the actual path of underground utilities followed closely the original plans of Engineering. But as any Civil Engineer in the phone industry with two months' experience knows, utility maps often reflect outdated routes or routes as "planned," not as "dug." With the "spaghetti" problems under streets getting worse, the incidence of mistakes and cost over-

HOWARD M. ANDERSON is Vice President of Geophysical Survey Systems, Inc., North Billerica, Mass.

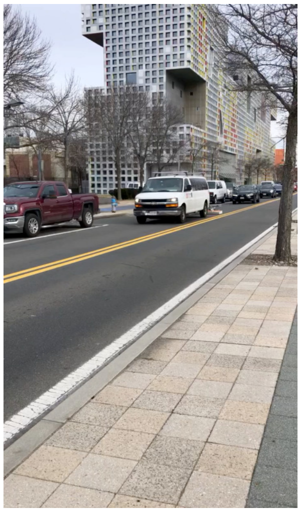
Courtesy of Telephony Trade Publication 1973

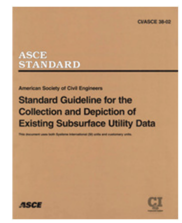
1973

Ground Penetrating Radar large or small. (GPR). ASCE 38-02 Quality Level B



Radar Tomography. Using wide array Ground Penetrating Radar (GPR). ASCE 38-02 Quality Level B





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Commercially Confidential / Michael A Twohig / DGT Associates

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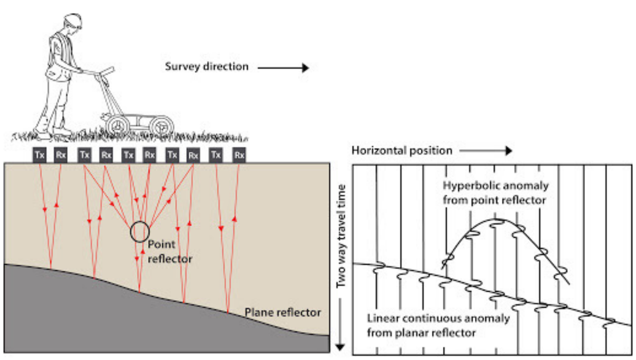
The GPR Method



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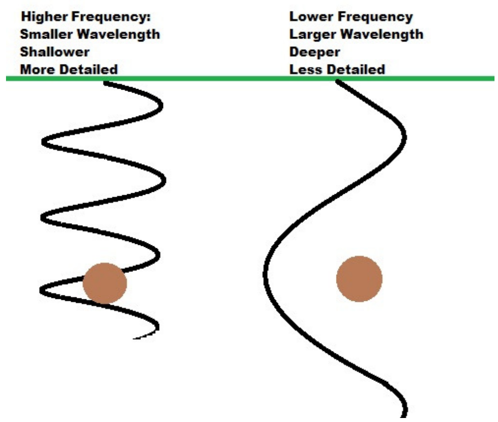
GPR Resolution



Antenna Frequency (MHz)	Penetration (m)[ft]	Resolution (cm) [in]
100	30 [100]	100 [40]
250	8 [26]	30 [12]
800	1.5 [5]	15 [6]
1600	0.45 [1.5]	6 [2.5]
2600	0.3 [1]	2.5 [1]

- Typical rule of thump - resolution ~**1in** per foot of depth

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GPR Collection

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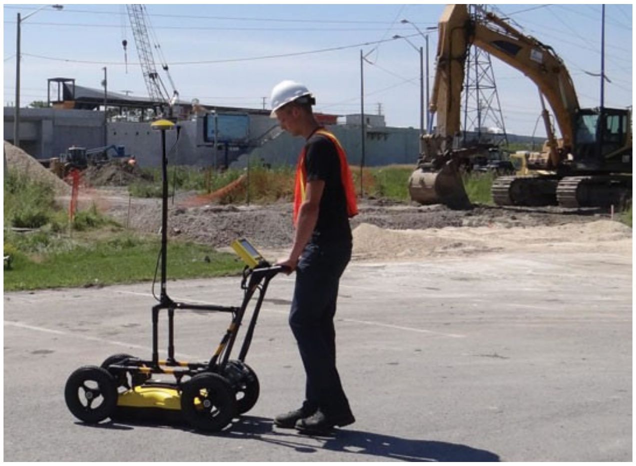
GPR Collection



- Common 2D GPR surveys use 1 signal frequency
- Collect 1 "slice" at a time at walking speeds

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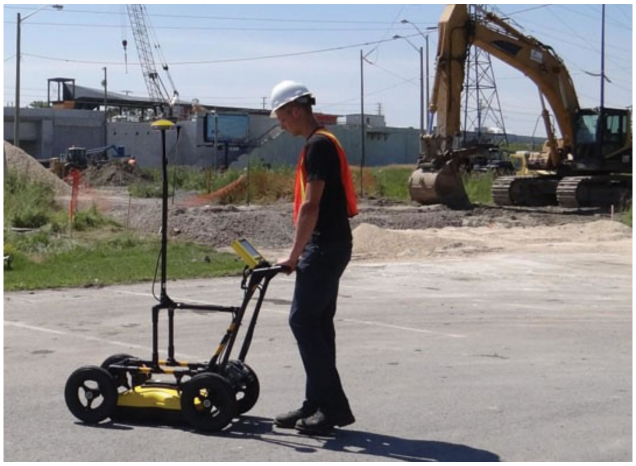
GPR Collection

PROS

- Versatile
- Accessibility
- Immediate identification of targets



CONS

- Slow collection
- Safety concerns
- Single frequency limits findings
- Not reasonable for large-scale collection

- Common 2D GPR surveys use 1 signal frequency
- Collect 1 "slice" at a time at walking speeds

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GPR Collection

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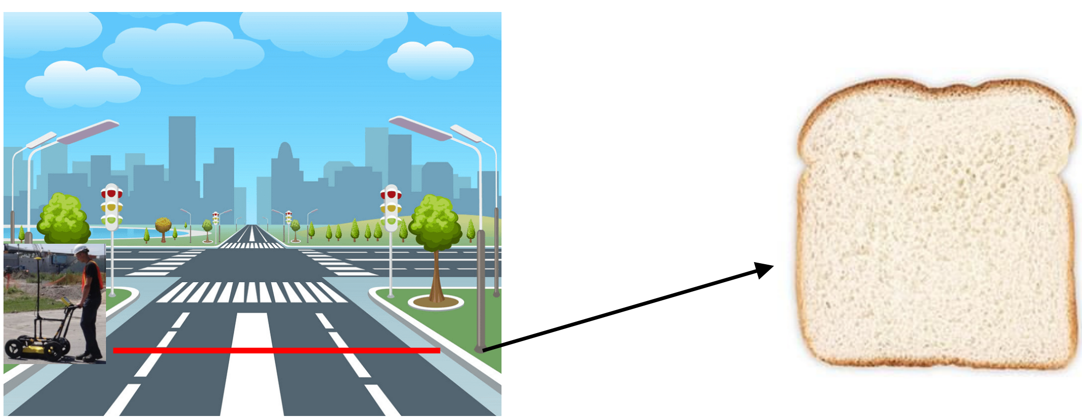
GPR Collection



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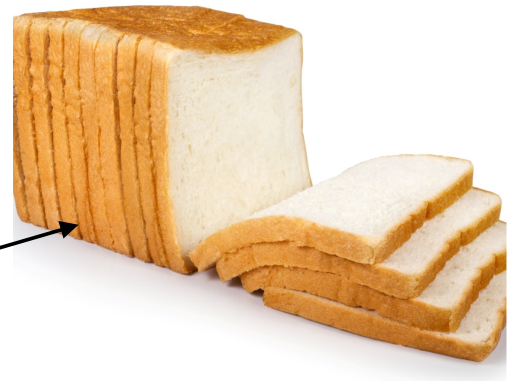
GPR Collection



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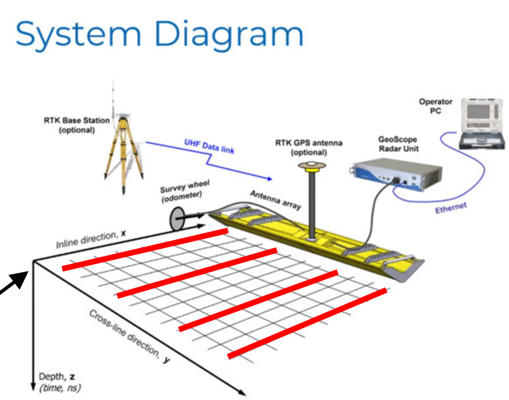
GPR Collection



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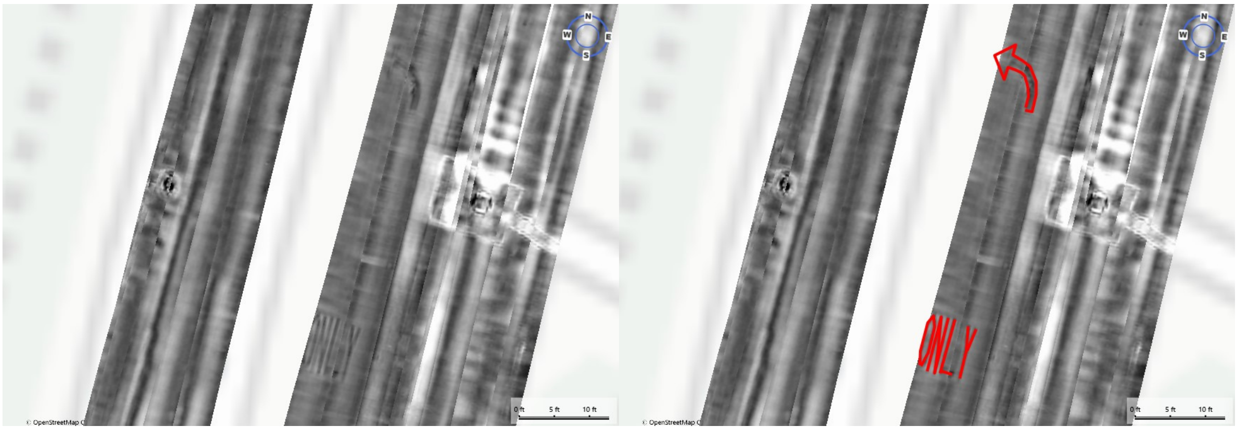
GPR Collection

61

GPR Collection

62

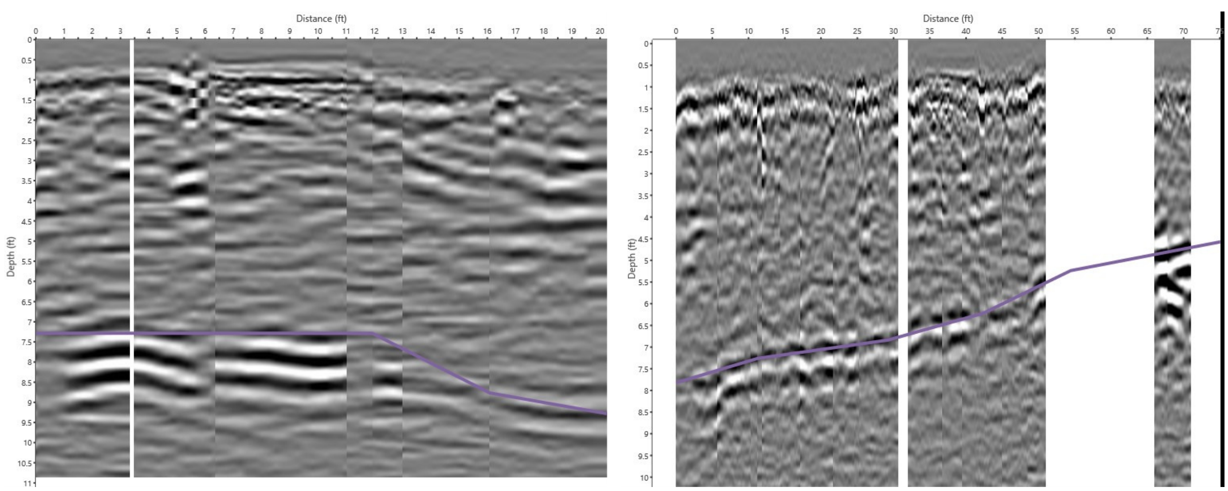
GPR Collection



- High frequencies allows high resolution near the surface

63

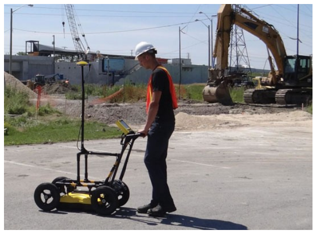
GPR Collection

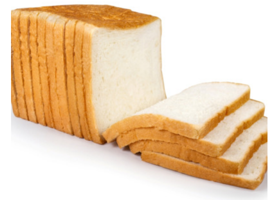


- Low frequencies allow resolution at depth

64

GPR Collection





- Single frequency push-cart is limited to one penetration depth and resolution
- Broad band collection has applicability at near surface and depth

65

GPR Collection

- ~10 miles of collection/day (max quality)
- 240 miles of GPR data (24 channels simultaneously)

- ~ 3 mph speed
- ~24 hours of walking to collect the same sq footage
- **80 hours (!)** to get comparable amount of GPR data

66

Value of GPR

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GPR Applications

1. Safer Utility Tracing

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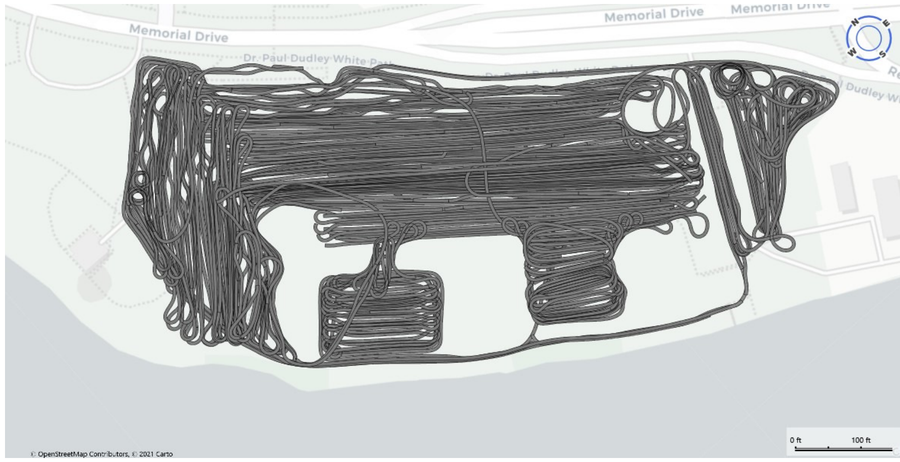
68

GPR Applications

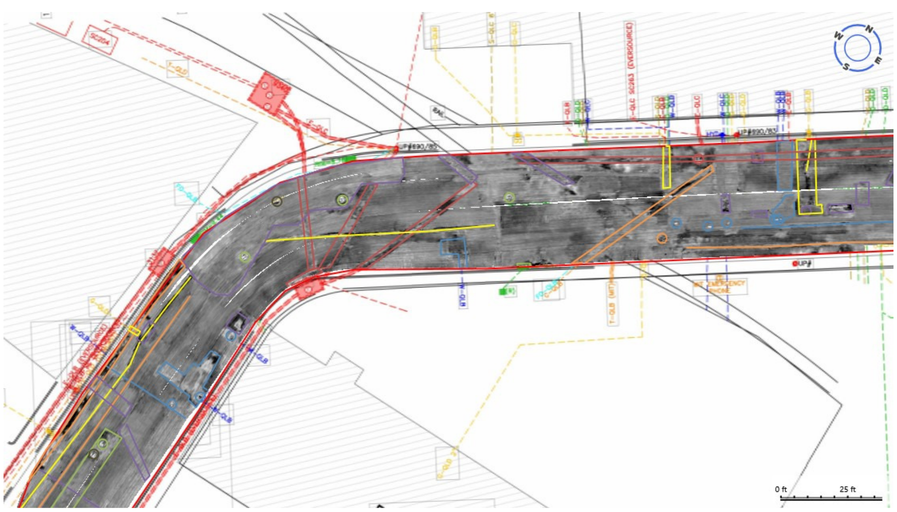
2. Fast Collection



- Data collected and processed in the field at driving speeds

69

GPR Applications



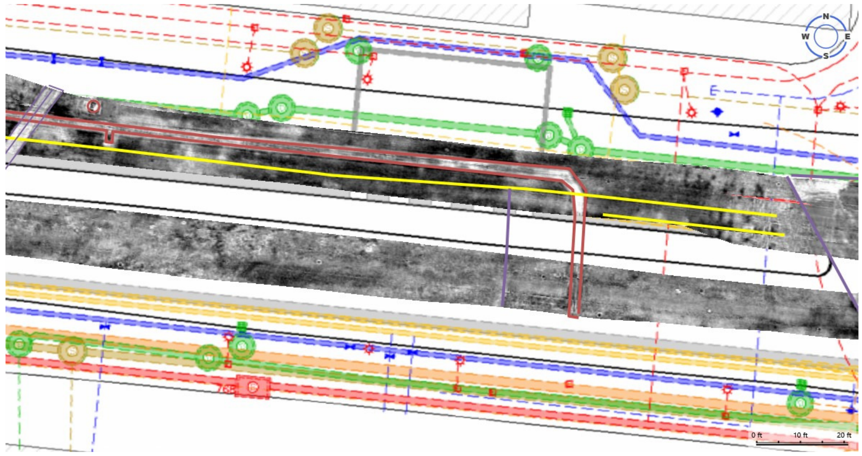
3. Confirming Locations

- Color-coded trench and pipe markings (Vassar Street)

70

GPR Applications

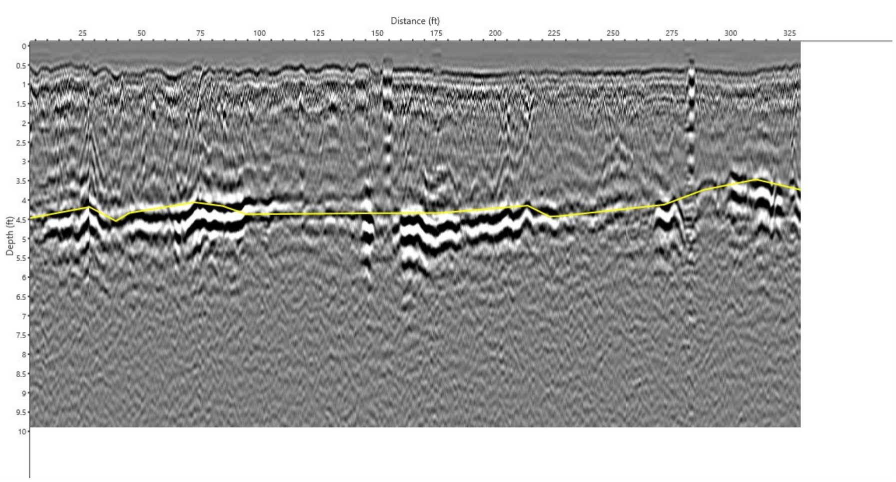
4. Finding Deviations



- Electric trench with previously unknown cross-street turn (Main Street)

71

GPR Applications

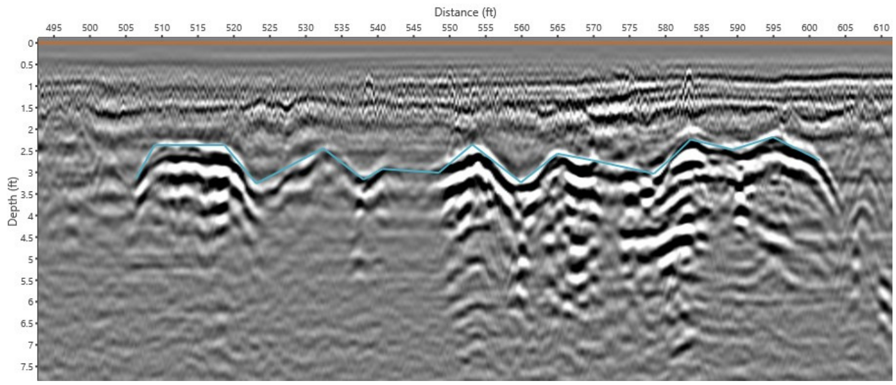


5. Determining Depths

- Gas pipe depth cross-section (Main Street)

72

GPR Applications



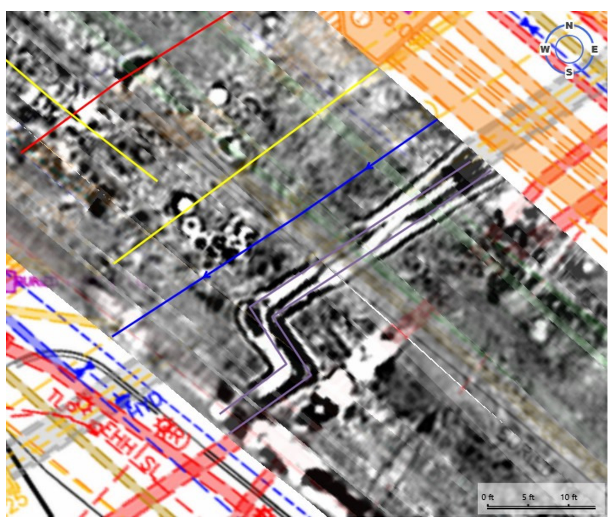
5a. Determining Depths

- Tracking the depth change of fiber optic cables (Mass Ave)

73

GPR Applications

6. Finding Unknown Features



- Unknown utility with 90-degree kink (Mass Ave)

74

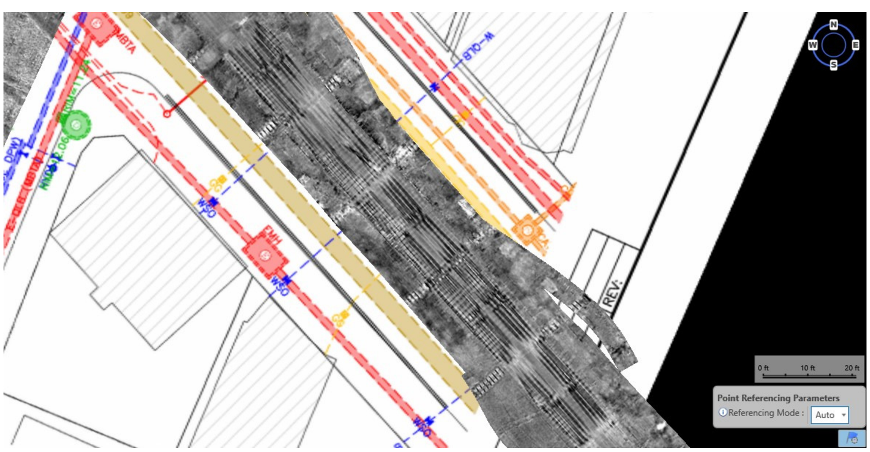
GPR Applications

6a. Finding Unknown Features

- Unknown chamber and pipe system with no surface expression (Linskey way)

75

GPR Applications

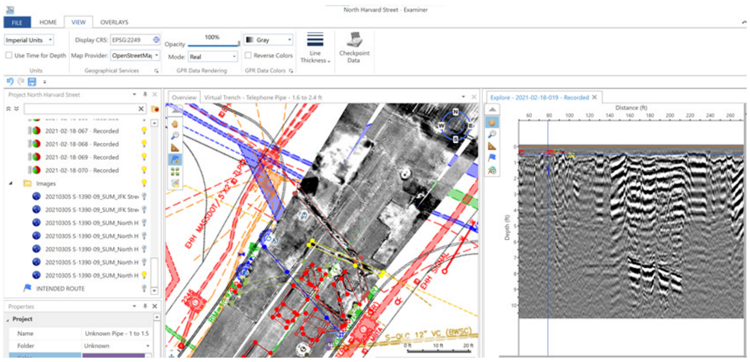


7. Confirming Excavation Ability

- Reinforced portion of roadway at 1ft depth (Hampshire Street)

76

Integrating GPR in SUM



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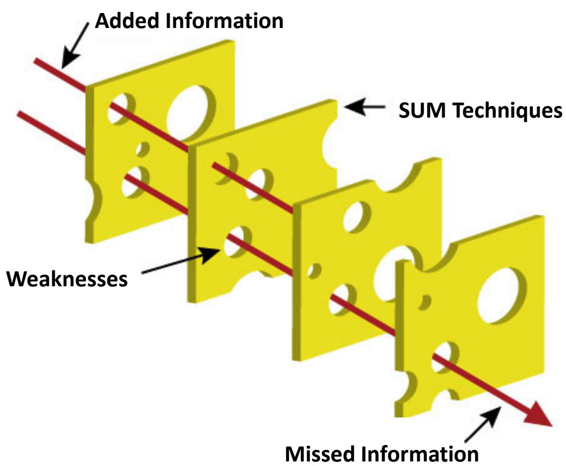
GPR in SUM

SWISS CHEESE MODEL



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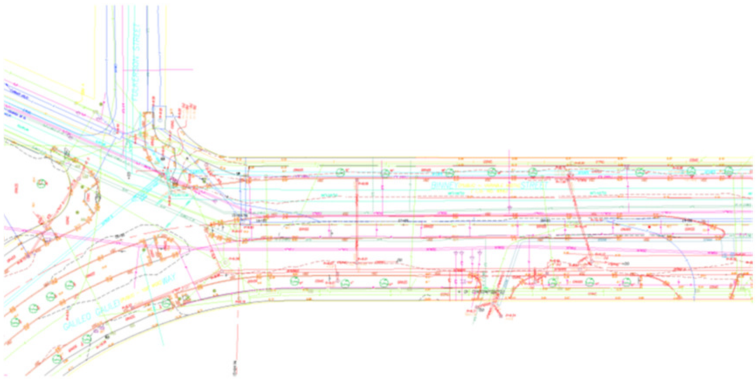
GPR in SUM



Legacy and existing maps

↓

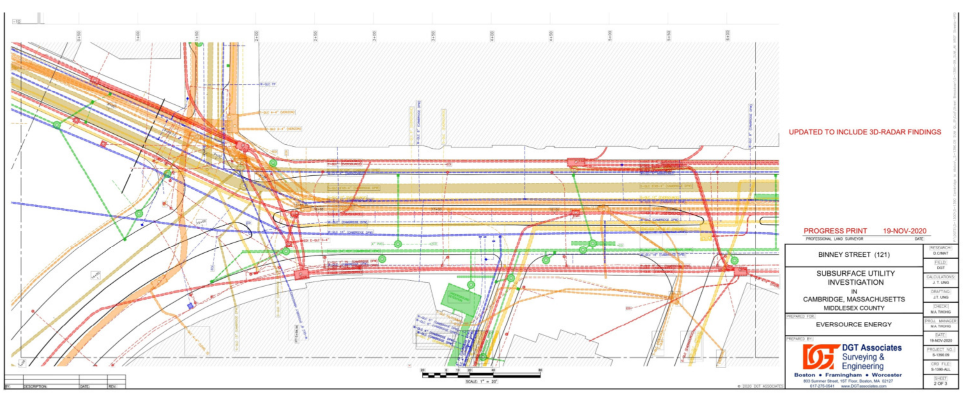
Institutional Knowledge

↓

EM Pipe location Data

- Holistic integration of GPR data begins with Quality Level C and D Map

GPR in SUM



Legacy and existing maps

↓

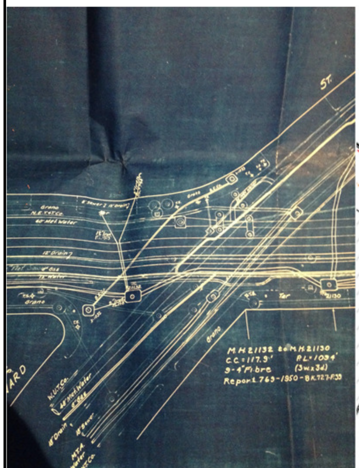
Institutional Knowledge

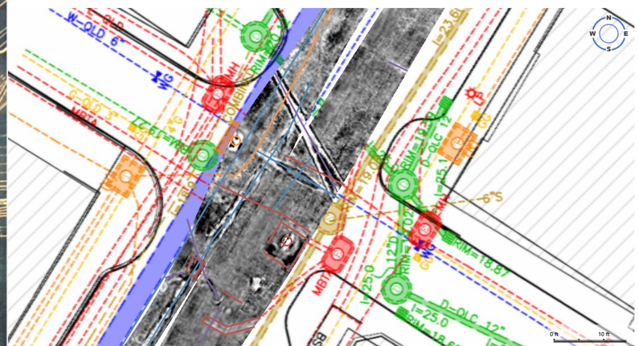
↓

EM Pipe location Data

- Fulkerson to Sixth Street with GPR information added

GPR in SUM





Data Processing

↓

Comparison to Maps

↓

GPR Locations and Depths Incorporated

- North Harvard Street legacy map informs analysis of modern GPR data

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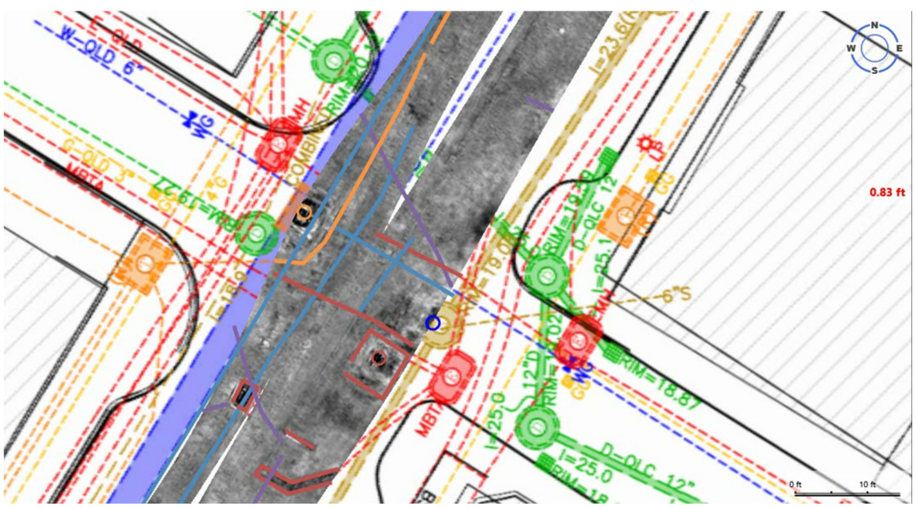
81

GPR in SUM



- GPR features correlated to known utilities
- Uncorrelated features incorporated into future deliverables

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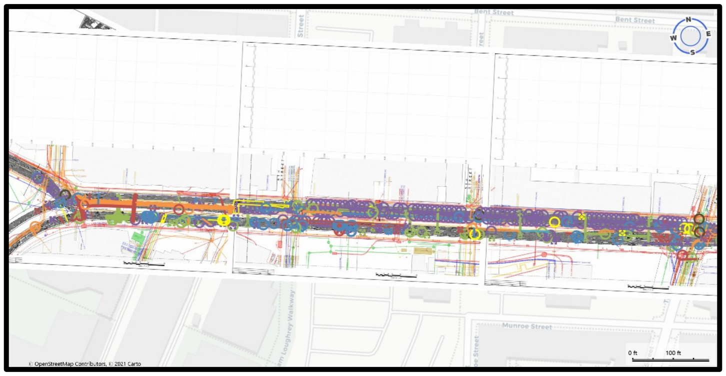
82

Binney Street



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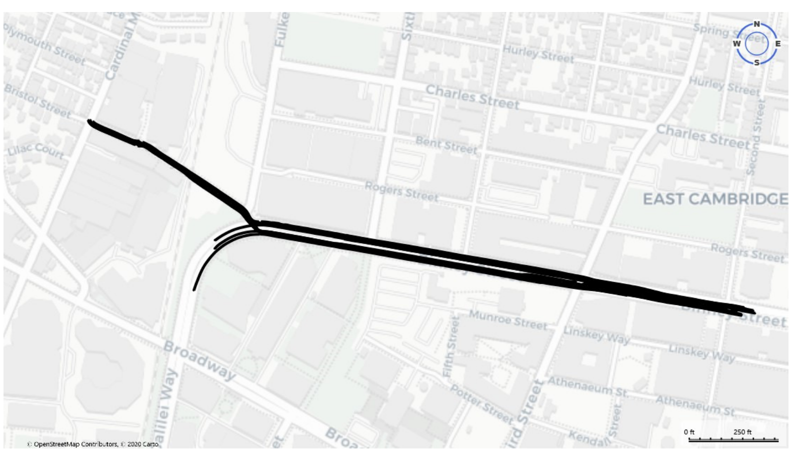
Binney Street



- Signals from 200 MHz to 1200 MHz

- Resolution of ~6in near the surface to 12in at depth

- 3200 linear feet → ~13000ft curb-to-curb

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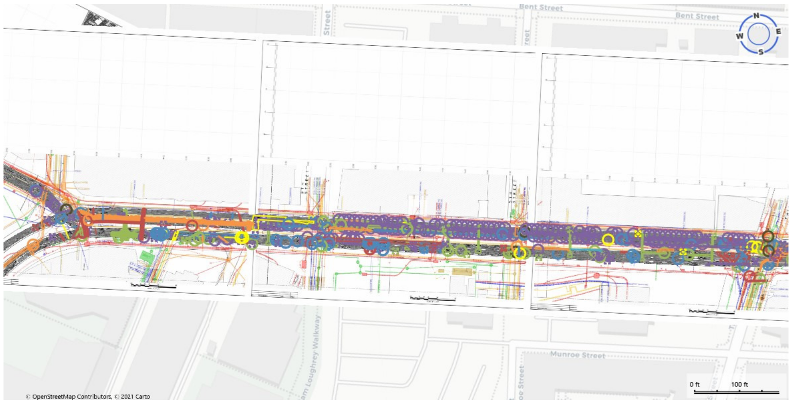
Binney Street – Findings



- 583 Total features identified in GPR data from **0.2 to 10 ft depth**
- 103 depth determinations to pipes or objects
- 211 Unknown/unconfirmed anomalies or trenches

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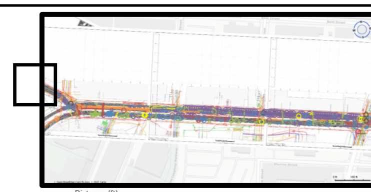
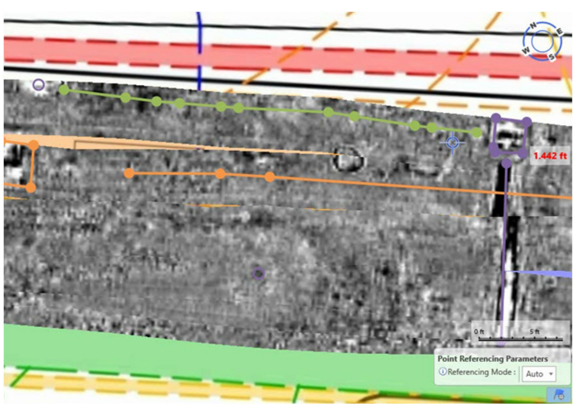
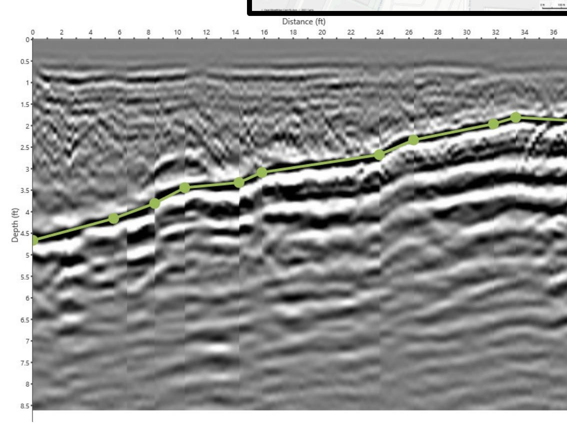
Binney Street – Findings







- Unmarked drain system in plan view with video and profile

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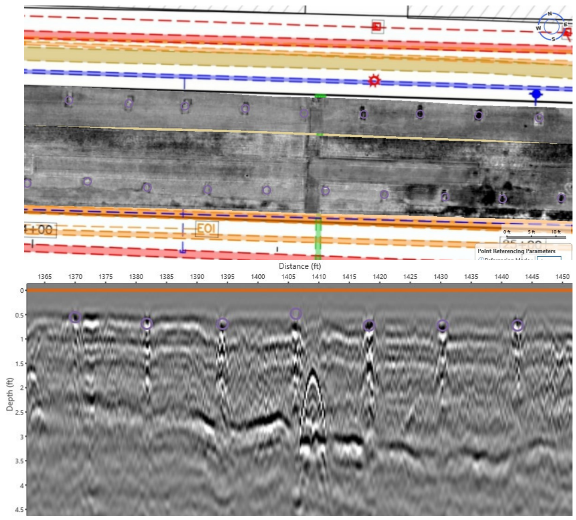
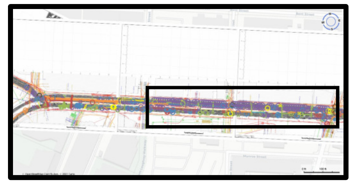
86

Binney Street – Findings

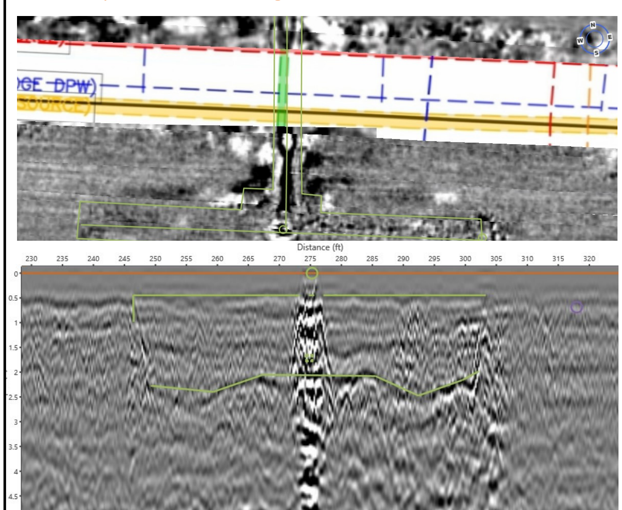


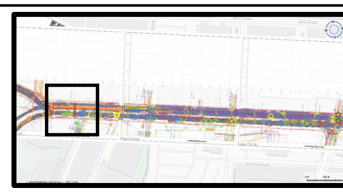


- Series of **~12ft regularly spaced** unknown rectangular anomalies or pits
- Only on **north lanes** from 6th to 3rd street
- Cross-section shows consistent depth and character of the anomalies

87

Binney Street – Findings

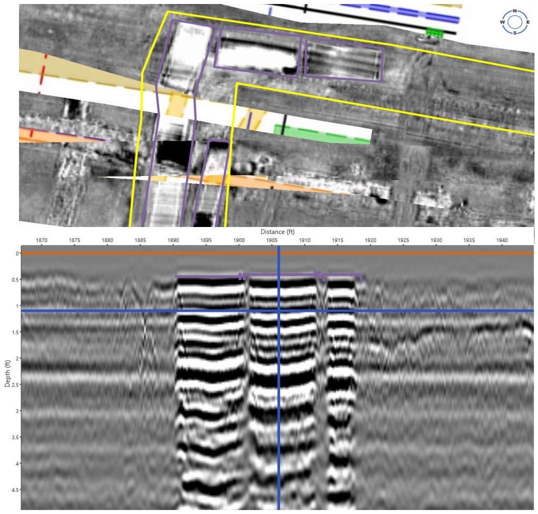


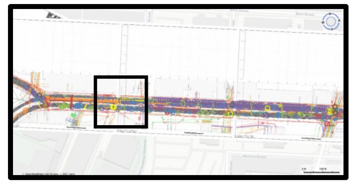


- Drainpipe leading to drain manhole visible at 3.3 ft depth
- Extent of detention system seen in cross section

88

Binney Street – Findings

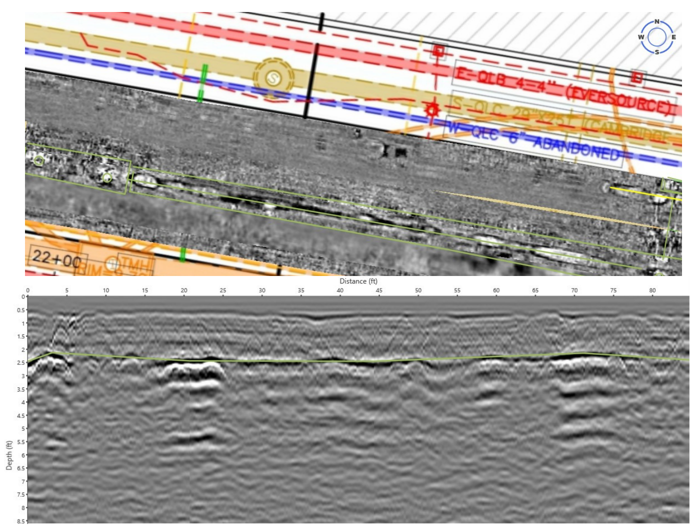


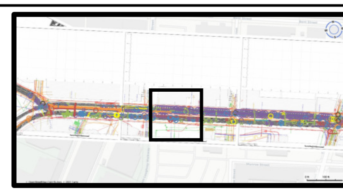


- Shallow metal plates at 0.3ft on top of a steam line
- Bright ringing reflection indicative of metal plates

89

Binney Street – Findings

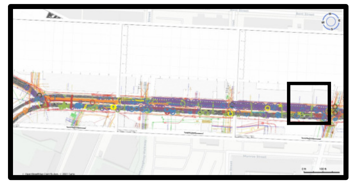


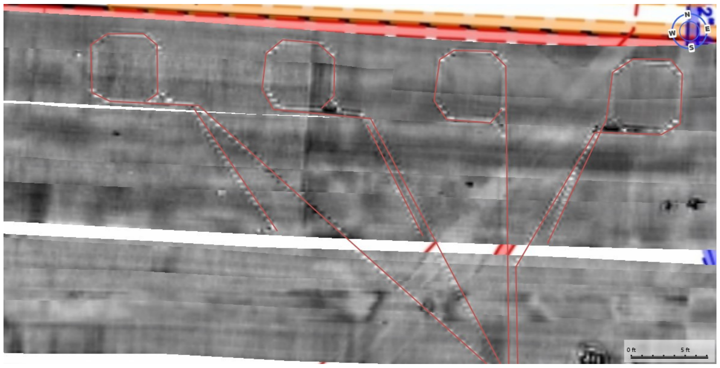


- Drainpipe visible at 2.5ft depth along street axis
- Traced via cross-section

90

Binney Street – Findings

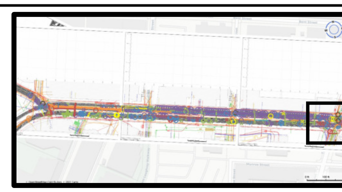


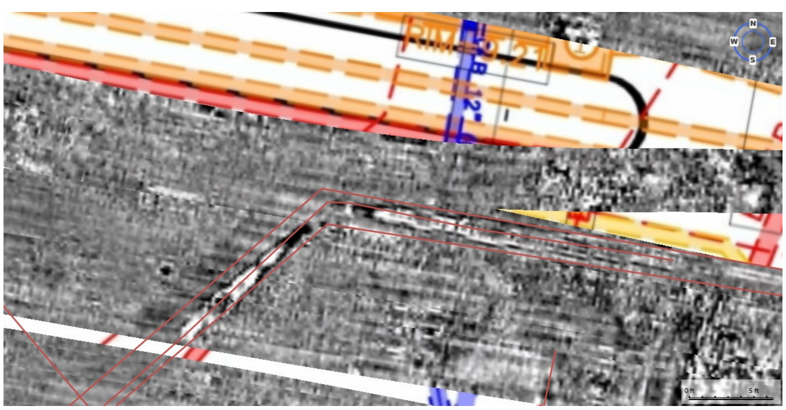


- Induction loops ~0.3 inches wide traced at 0.2 ft depth

91

Binney Street – Findings

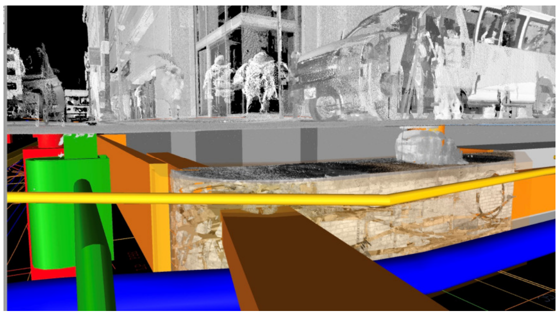




- Electric pipe depth determination at 1.6 ft near 3rd street

92

Finding the Z



- 2 and 3D Subsurface Utility Mapping programs

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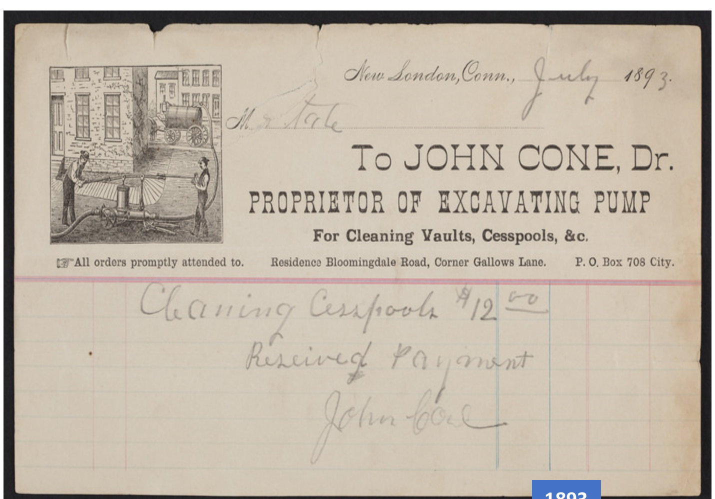
Non-Destructive Vacuum Excavation Systems



New London, Conn., July 1893.

To JOHN CONE, Dr.

PROPRIETOR OF EXCAVATING PUMP

For Cleaning Vaults, Cesspools, &c.

All orders promptly attended to. Residence Bloomingdale Road, Corner Gallows Lane. P. O. Box 708 City.

Cleaning Cesspools $12.00

Received Payment
John Cone

1893

Vacuum Digging (69-D-29)

JOHN E. COHOON, Assistant Engineer of Distribution
The Brooklyn Union Gas Company, Brooklyn, New York

SINCE the invention of the pick and shovel, there has been almost no advance in the method of digging the small-sized excavations in paved streets required for maintenance work on gas distribution piping. There has been some development of highly specialized equipment for small-hole clamping and the like; however, the majority of holes dug for joint clamping, service cutoffs, anode installations, etc., are still being done with a shovel.

About four years ago the concept of excavating small street openings by means of an industrial-type vacuum cleaner gained acceptance at The Brooklyn Union Gas Company. This is an extremely important concept to us because we make approximately 30,000 such openings each year, and even a small savings in labor or pavement restoration could result in substantial annual savings.

Some early experimentation was done using a small industrial vacuum cleaner in conjunction with a 160 cfm air compressor which proved the feasibility of the concept, but showed the necessity of developing some specialized hardware. This machine used a venturi effect to produce the vacuum and was neither convenient nor powerful enough for use in the field.

The project engineer in collaboration with field people developed the following criteria for an ideal digging machine for gas maintenance work:

It must be able to excavate a small street opening faster than a man with a shovel to justify the capital investment.

It must be capable of being operated in city streets without damaging other utilities.

It must be able to operate within a small pavement opening to avoid expensive pavement restoration, as shown in Figure 1.

It should be highly maneuverable to facilitate its use in streets with congested traffic conditions.

At this point it became necessary to find an equipment manufacturer who would be interested in working with Brooklyn Union engineers on the development of a vacuum digging machine which would meet these criteria. There are many firms which manufacture this type of equipment for cleaning catch basins and manholes; however, it took considerable search to locate a company interested in this new application.

After discussions with various dealers, the Myers Sherman Corporation of Streator, Ill., agreed to a joint project to design the desired machine. It was eminently qualified to undertake the project as it had many years experience in building not only the conventional manhole cleaners but various types of complex material-moving equipment based on the vacuum principle, one application of which is the loading and unloading of grain on ships for foreign delivery.

Brooklyn Union agreed to purchase one of its standard units and conduct field testing to determine what modifications would be necessary to meet the design criteria. This machine had a 16½ cu yd body with a separately powered fan mounted on a C750 Ford truck chassis. The pick-up hose was 8 in. in diameter and operated in a 120° arc. The overall length was over 20 feet.

Field testing was conducted over a period of several months. It was obvious that depending upon the type of soil and the method used to loosen it, this machine would be able to excavate from 1½ to 2 times as fast as a man with a shovel. The field testing also developed some problem areas which would need correcting if the machine were to be of practical use. These problems were as follows:

Size—The overall vehicle-size must be small enough to use in congested city streets, but must have sufficient capacity to receive the excavated material from several openings.

Control of the Tube—The control of the digging tube must be easy and accurate so that the operator can continue to work without excessive fatigue.

Clogging of the Tube—The tube must be constructed in such a way that it is flexible, will rotate around the truck and must be fabricated of a material to which the spoil will not adhere.

Loosening the Earth—Tools and accessories must be designed to loosen compacted earth and clay so that the vacuum digger tube can remove it.

Unloading the Spoil—There must be a convenient way to unload the spoil so that it does not interrupt the digging operation.

Velocity of Air Required—Sufficient velocity of air through the tube must be developed to carry any excavated material which will pass through the tube.

Necessity of Having Compressor Truck Available—There must be a 125 cfm air compressor as an integral part of the truck so that the truck operators can break pavement without depending on outside help. This makes the truck a self-contained unit.

Excessive Noise—The machine must be designed with the necessary mufflers so that noise level does not create a nuisance.

The new vacuum digging machine which was designed and built by Myers Sherman to overcome these problems is called the Excavactor and has the following characteristics:

Length 223"—Wheelbase 135"—Ford Chassis
Weight—16,000 (unladen)
Engine 391 Cu. In.—with 5652 Spicer Transmission which develops 160 hp at 2600 rpm (fan operating speed), P.T.O. for hydraulic system, air compressor and fan
Suction—Operating pressure of 10" hg vacuum at 3000-4000 cfm
Compressor—125 cfm at 100 psi
Hose and Boom—6" wax impregnated hose which rotates approximately 270°

When these specifications are compared with those of the standard machine, it becomes apparent that most of the design criteria have been met and many of the problems overcome. The new machine which is called the Excavactor was delivered late in 1968 and only limited field testing has been done, the results of which are shown in Table I.

The principle underlying the operation of the Excavactor can be readily understood by reference to Figure 2. A high speed fan is used to produce a partial vacuum in an air-tight chamber so that air will be drawn through an inlet hose at a high velocity. This high-velocity air picks up the particles of earth, carrying them into the chamber, where the particles drop out of the air stream as it loses its velocity. The Excavactor operates at a vacuum of 10 in. hg which is sufficient to carry away any stone which will pass through the 6 in. digging hose.

We lift out the asphalt and concrete when it has been broken small enough and when we are not concerned about the quality of the backfill.

The Excavactor consists of hopper-shaped air-tight chamber with a capacity of 3 cu yds from which air is evacuated by a fan operating at 2600 rpm. The fan is powered from the truck engine by a split-shaft power take-off unit. The suction or digging hose is 6 inches in diameter and is constructed of wax impregnated rubber to eliminate clogging and is swivel-mounted so that it swings in an arc of 270°. The vertical position of the hose is controlled hydraulically from a portable control held in the operator's hand; however, it must be handled from side to side.

This represents one of the unsolved problems as it is a difficult and fatiguing operation which severely limits the number of jobs completed each day. The Excavactor was made self-sufficient by inclusion of a 125 cfm air compressor powered by a power take-off. This permits the crew to break their own pavement openings rather than depending upon a compressor truck.

The hopper was designed at 3 cu yds because this is an optimum size both from the standpoint of truck size and required capacity since it was felt that excavations would be backfilled almost immediately.

This paper was presented at the 1969 A.G.A. Operating Section Distribution Conference. The views expressed are the author's and do not necessarily represent those of the American Gas Association. Printed in U.S.A.

D-176

1969

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94

Locating Utilities Has Been a Rudimentary Process for 100 Years

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Any interference or problems in the designation phase of a project should be resolved using vacuum excavation.

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ASCE 38-02 Quality Level A. Survey grade accuracy.

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ASCE 38-02 Quality Level A. Survey grade accuracy.

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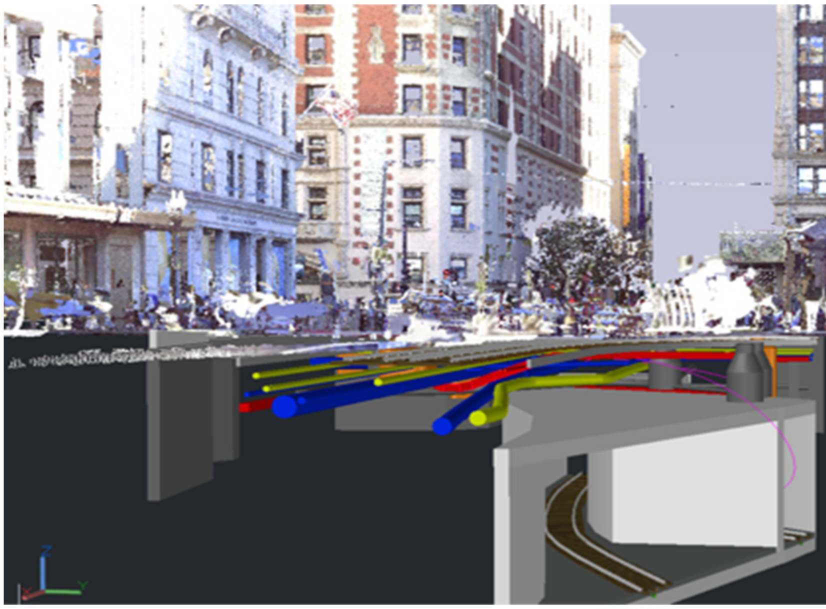
98

Questions?



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99

Things About Instrumentation You May Have Forgotten or Never Learned

Joseph Paiva, PhD, PS, PE

2022 MALSCE Convention
Leominster

1

Outline

- Highest priority things to check - things to get your field people to constantly monitor
- Easiest things to check - things your field people must learn to do daily
- Most difficult things to check and how to do these
- Operational/equipment suggestions

2

2

Highest Priority

- Level bubble and/or compensator check (every setup)
- Optical plummet check (every setup)
- Tripod stability (including tripod components)
- Cleanliness of instrument case (dust, vacuum)

Highest Priority

- Accessories in instrument case
- Checklist for things like batteries, charging, history, other checks, repairs
- Transfer data to in-house records

Highest Priority

- Prism pole bubble check (daily)
- Prism pole check (bent, warped, point, etc.)
- Prism check (cracks, confirm constant, clean)

5

Highest Priority

- Tribrach check (snugness of fit, lock smoothness)
- Clean
- Grease? (service shop only)
- O.P. in tribrach check (weekly)

6

Highest Priority

- Horizontal cross hair on auto or digital level
- Get rid of well-used level rods, prism poles, antenna poles, cracked prisms, cracked/broken tripods, etc.

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7

Easiest to Check/Do

- Optical plummet check on alidade or anything rotatable
- Reversing point of tubular vials and digital vial tubes based on compensator
- Adjust electronic compensator on instruments with “0 Set” key or menu selection

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8

Easiest to Check/Do

- "Eyeballing" tripod, components and nuts, bolts, hinges, etc.
- Once learned, checking bubbles on tribrachs
- Once learned, bubbles on prism and antenna poles
- H and V collimation checks

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9

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10

A Bit Harder

- Optical plummet tribrach (includes laser plummet)
- Trunnion axis adjustment (shop)
- Any reticle adjustment (shop)
- Any collimation adjustment of secondary technology on basic instrument (EDM, auto target seeking device, laser pointer, video/still camera)

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11

Optical Plummet

- Understand why this is important
- Is it working correctly?
- How to check?
- What is implication of inaccurate plummet?

Why?
What good is measuring an angle at a point that you didn't intend?

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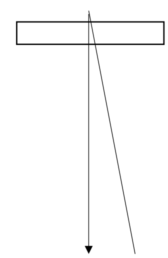
12

If Your Optical Plummet Or Leveling is Out

- What Are the Implications?
- Let's say it is 5" or 10" or 20" or 30" or 60"

- $offset = \tan 5" \times 5 = 0.0001\ ft$
- $offset = \tan 60" \times 5 = 0.001\ ft$



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13

But Look At It Correctly

- Optical plummet misses point by 0.01 ft (case 1)
- Or level bubble is out of adjustment by 30" (case 2)

- Case 1: $\theta = tan^{-1}\frac{0.01}{5} = 6'32"$
- Case 2: see previous slide (negligible)

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14

Collimation and Compensator Errors

- Zenith angles
- You measure 91°00’00”
- But because of collimation error, the angle is *really 91°00’30’*
- What is impact on positioning
- Zenith angle affects reduction of slope distance to horizontal AND determination of vertical distances when elevations/heights are being determined

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Collimation and Compensator Errors

- Zenith angles
- You measure 91°00’00”
- But because of collimation error, the angle is *really 91°00’30’*
- Slope distance, let’s say you measured 500.00 ft
- Using the *correct* zenith angle, $H = \sin 91°00'30" \times 500 = 499.923\ ft$
- Using *incorrect* zenith angle, $H = \sin 91°00'00" \times 500 = 499.923$

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Collimation and Compensator Errors

- Zenith angles
- You measure 91°00’00”
- But because of collimation error, the angle is *really 91°00’30’*
- Slope distance, let’s say you measured 500.00 ft
- Using the *correct* zenith angle, $V = \cos 91°00'30" \times 500 = -8.799\ ft$
- Using *incorrect* zenith angle, $V = \sin 91°00'00" \times 500 = -8.72\ ft$

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Collimation and Compensator Errors

- Horizontal angles
- You measure 178°00’00”
- But because of collimation error, the angle is *really 178°00’30’*
- Horizontal distance of 500.00 ft
- Using the *correct* horizontal angle, assuming N0.0, E0.0 for instrument, P is at N –499.698, E +17.377
- Using *incorrect* zenith angle, P (N –499.695, E +17.450)

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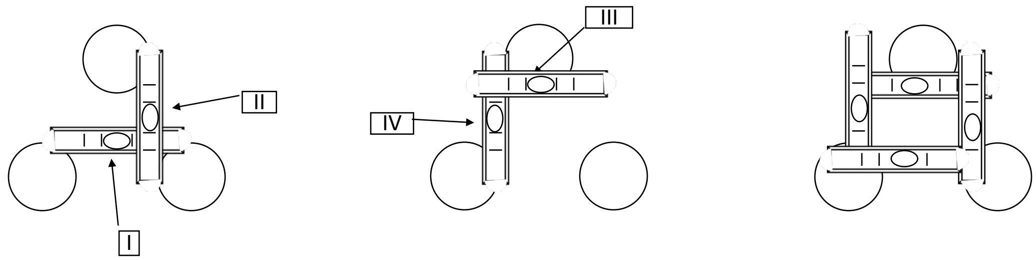
Adjusting for Reversing Point on Compensator



BTW: most experienced operators can center within 1/5 of span of 2 mm graduations. So, if 30" bubble, ±6" centering.

Bubble movement at III indicates TWICE the error in bubble adjustment

Key is to find REVERSING point…where bubble stays in same position as you rotate alidade

Where/How To Get Weather Info

- Use barometer!
- NOT your phone, bank sign, radio, weather bureau report, etc.
- Electronic devices now available for phone, phone apps and stand alone handhelds
- All instruments used for pressure must be periodically calibrated against a mercury barometer
- Temp should be in shade, about 5-6 ft above ground

Atmospheric Pressure Measurements

- Do not use weather reports; they report pressure as if the barometer is set up at sea level, even if you are in Denver
- That information is useless for correctly applying pressure correction
- Weather station might report 29.92” of Hg but the pressure at the surface in Denver will be about 5” lower!
- At altitude the elevation dominates over atmospheric pressure changes day-to-day (with some caveats)

Sensitivity of Prism Pole Bubble, etc.

- If you can’t get your distributor or manufacturer to give you a reliable number for the sensitivity of your leveling bubbles (tubular, circular and electronic), maybe you should find another supplier
- There are some approximate ways to get these values yourself with your basic surveying instruments

Calibration of Tape

- Why talk about this?
- Because surveyors sometimes have trouble with this concept

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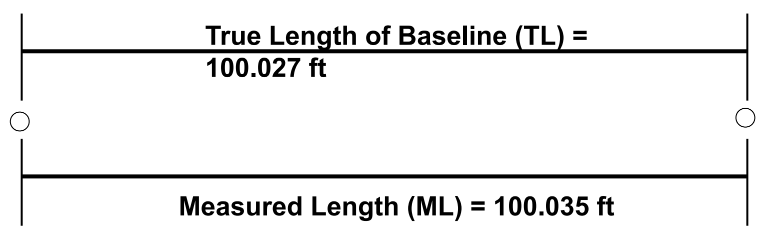
23

Tape Calibration



What is the true length of the tape?

i.e. what is the length between the zero and the 100 ft marks?

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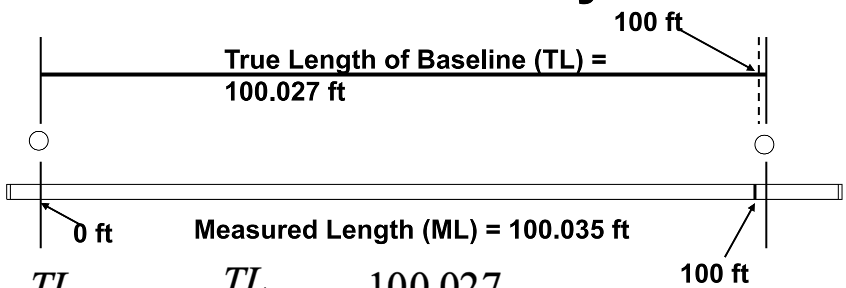
24

Calibration Analysis



$$\frac{TL_{tape}}{ML_{tape}} = \frac{TL_{baseline}}{ML_{baseline}} = \frac{TL_{tape}}{100.00} = \frac{100.027}{100.035}$$

[99.9920028]

Alternatively

100.027
.035 –
99.992

25

Measuring vs. Measuring OUT

- You have an EDM that you know is running long, meaning, it gives you an incorrect value that is larger than the correct value
- i.e. It indicates 200.00 ft when you actually have 199.96 ft
- You measure the distance two points and get an indicated value of 350.00. What is the true length?
- Error is 0.02/100 ft
- Total error is 0.07
- Correct, i.e. true length is 350.00 – 0.07 = 349.93

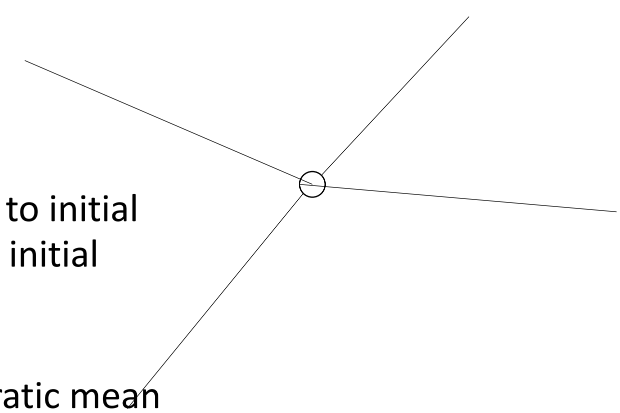
26

Measuring vs. Measuring OUT

- You have an EDM that you know is running long, meaning, it gives you an incorrect value that is larger than the correct value
- i.e. It indicates 200.00 ft when you actually have 199.96 ft
- You want to measure the distance two points and to get a true value of 350.00 between them. What should you measure?
- Error is 0.02/100 ft
- Total error is 0.07
- Correct, i.e. indicated value is 350.00 + 0.07 = 350.07

How DIN Values Are Measured

- 4 targets
- 4 sets of F1/F2
- Calculate average direction
- Calculate 16 residuals
- Average for each round, apply to initial
- Reduce each other residual by initial
- Take sq. rt of (sum of the sq.)
- Divide by n-1, i.e. 15
- Run four times and take quadratic mean



Data for Least Squares

- Do not use mfr values
- Estimate multiplier to apply
- Depends on your methods, how many times you measured and averaged, condition of equipment, condition of crew
- Best if you have a system that lets you put in each individual measurement

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29

What About…

- Prism constant
- Instrument constant
- Optical plummet on tribrach
- Heating/cooling of instrument
- If the line is long enough are you considering temperature and atmospheric pressure
- Is the setup stable
- How long does it take to collect your measurement

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30

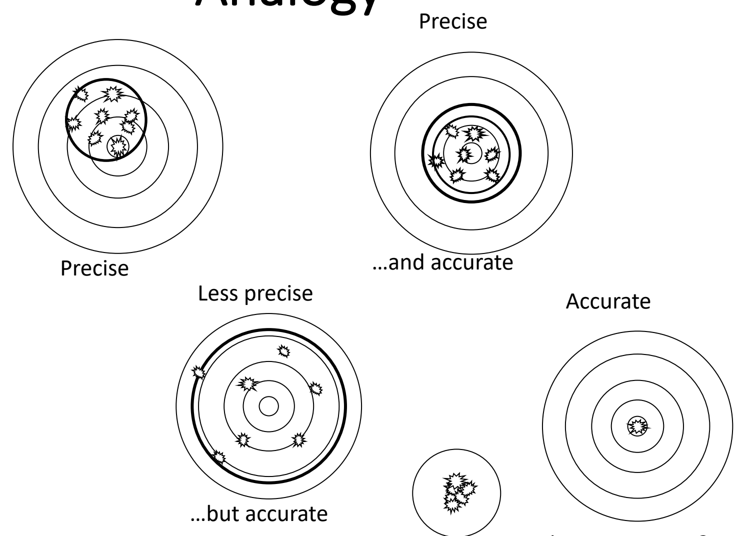
What About…

- Vibrations from construction, traffic, trains, foot traffic
- Frozen ground, windy day
- Warping of the instrument from sunshine
- Do you let the sunlight directly hit your bubble/compensator?
- All these factors affect the uncertainty level you should plug into your least squares software
- If you haven't done the experiments to determine impact from these factors at least use factor of safety of 2 – 5 (YES)!

Hint

- You WANT scatter in your values to demonstrate that you are actually picking up variations due to random error
- BTW if you want random error analysis that works, measure 8-10 times at least

Analogy



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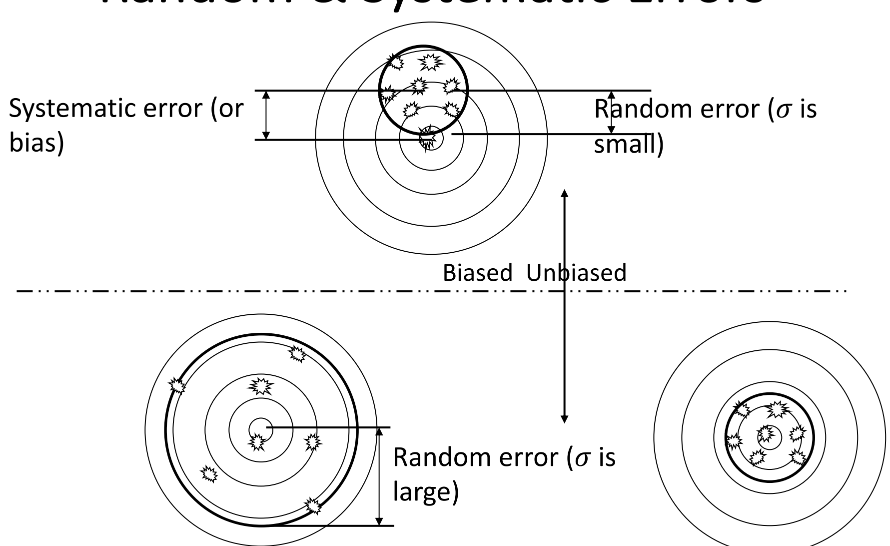
33

Random & Systematic Errors



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34

Analysis of Distance Measurements

If 1762.01 is rejected, average and σ must be recalculated

- 1762.56 ⟵
- 1763.03 ⟵
- 1762.74 ⟵
- 1762.98 ⟵
- 1762.01 ⟵
- 1762.49 ⟵
- 1762.80 ⟵
- 1762.79 ⟵
- 1762.68 ⟵

- Average is 1762.676
- sigma = 0.287
- 1762.38 to 1762.96
- 2sigma = 0.574
- 1762.11 to 1763.25
- 3sigma = 0.861

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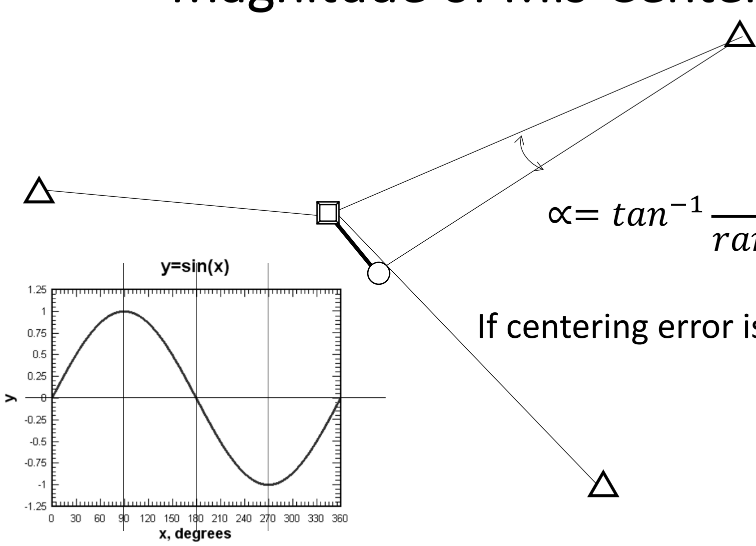
35

Magnitude of Mis-Centering – H. Angle



$$\propto = tan^{-1} \frac{centering\ error}{range\ to\ observed\ point}$$

If centering error is 0.02 ft and range is 100 ft,

$$\propto = 41''$$

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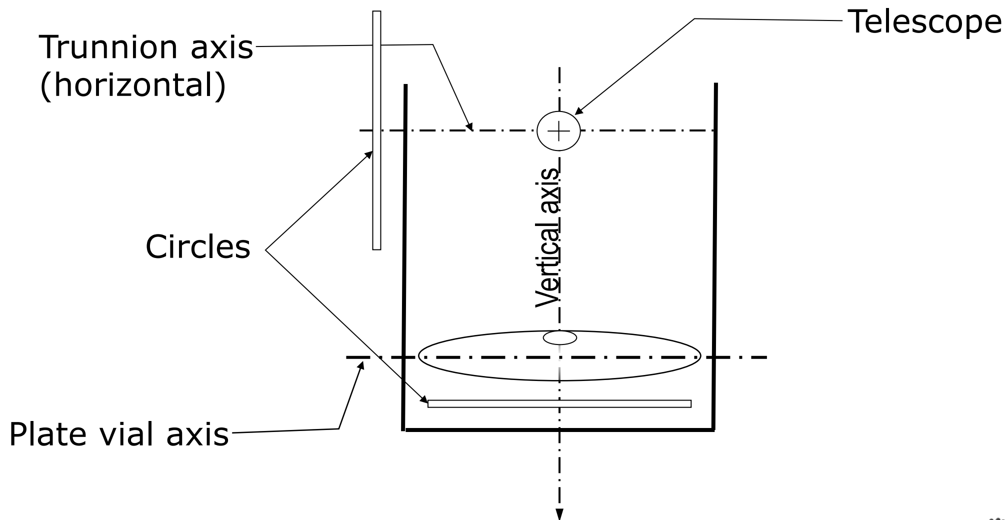
36

Basic Alignment of Theodolite



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37

Collimation

- Is cross hair aligned with optical axis of telescope?
- How to check
- Basic procedure is get a nice clear, sharp target about 150-250 ft away (close to horizontal, i.e. Z=90°); this distance depends on quality of instrument and magnification—you may need to be only 50-75 ft away
- Level up instrument and sight at the target in F1, record H and Z readings
- Invert into F2, sight target, record H and Z readings

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38

Interpreting Readings

- What should you observe?
- This should be obvious if you know your instrument

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Collimation Check

- Example data
- F1 H = 236°14’32”, Z = 87°15’16”
- Above values should be <u>mean</u> of four to eight sightings
- F2 what should you get if it is in good adjustment?
- Again, take mean of same number of readings as in F1

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Collimation Check

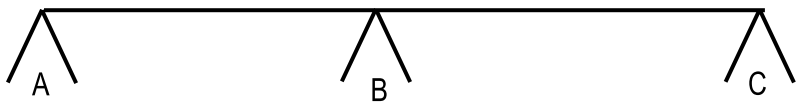
- Example data
- F1 H = 236°14'32", Z = 87°15'16"
- Above values should be mean of four to eight sightings
- F2 H = 056°14'36", Z = 272°44'50"

- Conclusion: variation in H is 4", variation in Z is 6"
- H error +2" Z error +3"

EDM Check – Prism Constant

- There are constant errors (fixed errors) in all EDMs
- We compensate for these with (a) an instrument offset (usually only set in the shop), and
- (b) prism constant (user settable)
- To test for the combined effect of these two error sources…
- Find a flat area about 250 ft long
- Set points at ends and middle (pacing is OK)
- Optical plummets must all be at the "no visual error" level

Determining Prism & Instrument Offsets



AB + BC should equal AC

If error exists (***e***), then it will be in each of the measurements, thus

AB + BC – AC = ***e***

Important Pointers

- Keep observations as flat as possible
- Use only one prism for all readings
- You can repeat with other prisms to see if you get different results
- Set your instrument to what the manufacturer tells you the prism constant is
- Any other difference is <u>possibly</u> due to instrument constant
- There can also be small variations in prism constants!

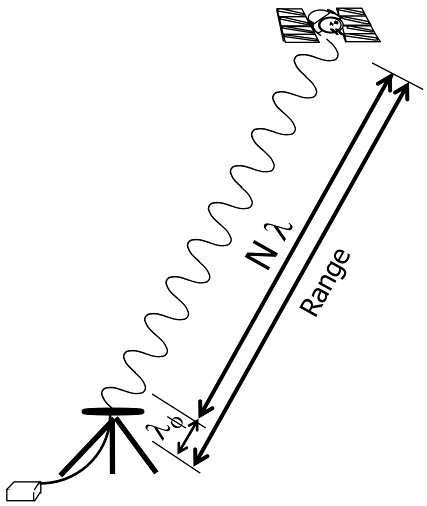
GNSS Buffer (under trees, in canyons, etc.)

- Cannot violate laws of physics
- Most RTK systems have a "buffer"
- Wait for system to settle before measuring an epoch or more
- Repeat occupations with "quick" RTK fixes will only reinforce the systematic error
- Set two good points in the clear (three best for redundancy)
- Then set up total station on each and calculate position of GNSS point and/or position of point that is shadowed

Faulty GNSS RTK Initialization

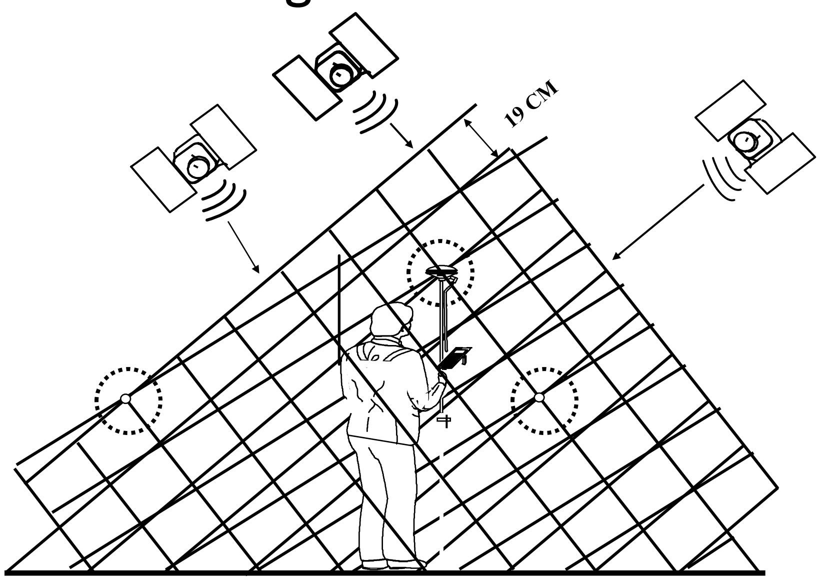
- RTK is not perfect
- Manufacturer's spec doesn't duplicate real life
- What's there in real life that's not in the test?
- Multipath
- Shadowing resulting in smaller number of satellites
- Latency
- Space weather
- Do you look at skyplots anymore?

The Integer Ambiguity



- Receiver measures partial wavelength when it first locks on
- Partial, circularly polarized phase is read like a clock
- Receiver counts successive cycles after this
- Receiver does not know whole number of wavelengths (behind that first partial one) between it and SV

Integer Resolution



Faulty Initialization Mitigation

- Occupy all points or key points or control points more than once
- When you do the re-occupation, break lock and re-initialize
- Occupy known control set by either/and other different methods, different bases, different time of day; usually guarantee of different constellation
- Static GNSS is accurate because satellites move during observation
- Very little movement with RTK/RTN even 3-5 minute occupations

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Close Your Traverse

- With total station, this is easy
- Have we forgotten!
- BUT….precision can be meaningless if you've not attempted to deal with systematic errors
- Measuring all distances that are 1% too long will still give you good precision
- So don't black box it!

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Adjust Your Traverse

- Whether it is compass rule or least squares, purpose of adjustment is to mathematically, theoretically account for random error
- IT is NOT supposed to deal with systematic error
- To deal with systematic error, know your instrumentation system and the environment

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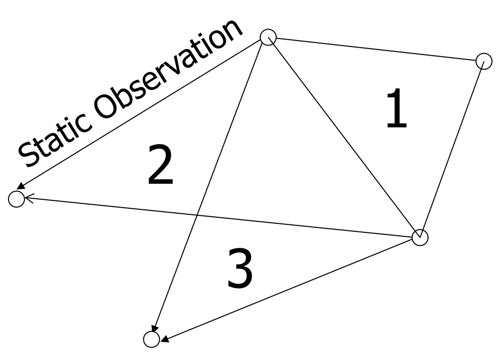
51

Adjust Your Static GNSS Positions



- Yes, you can traverse
- Solve the baselines that form triangles
- Now use those distances to calculate traverse triangles
- Do they add up to 180?
- Another option: proper least squares adjustments
- OPUS is great but don't take it and run!

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52

Adjust Your RTK GNSS Positions

- If you are using RTK, you are doing a radial survey
- How do you adjust your positions?
- One way is to set up a new hub for your radial measurements
- Or use RTN with redundancy
- As usual always check into know control periodically
- If possible observe at a different time to swap out the constellation

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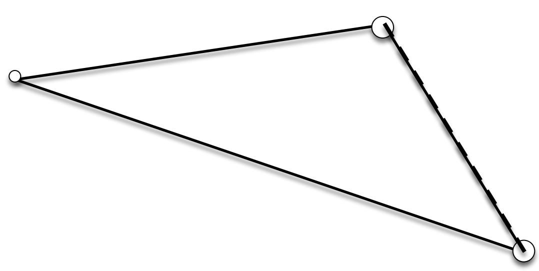
Static GPS Independent Baselines

- Biggest blunder is not having independent observations (after blunder of not setting up on correct point)



3 receivers; 1 session

Only 2 independent baselines

One more session with 2 receivers

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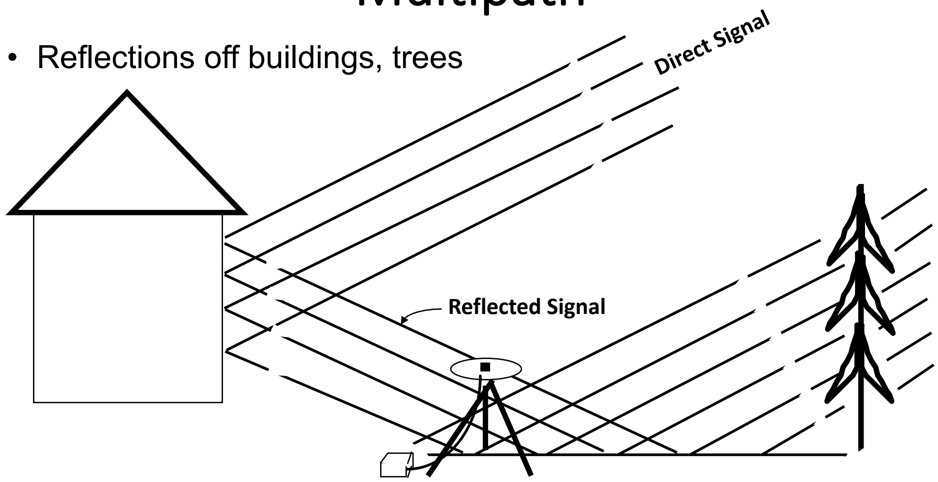
Multipath

- Reflections off buildings, trees



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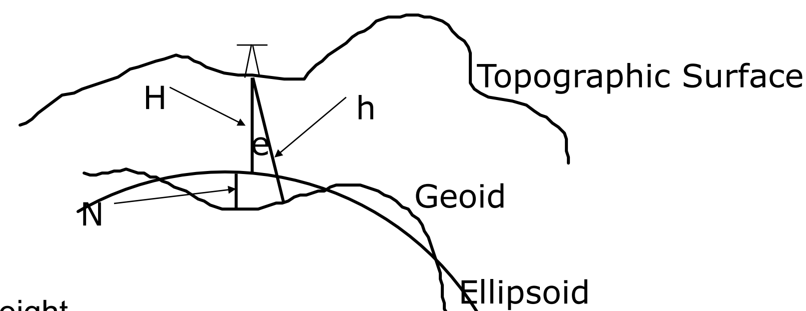
Geometric Relationships



H = Ellipsoid Height
h = Orthometric Height
N = Geoid Undulation

H = h + N
e = Deflection of the vertical

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Coordinate Systems

- GPS measures in WGS-84 Cartesian
- Surveyor could be using SPCs, UTMs, other systems—*never* WGS-84
- Converting from "native" GPS system to surveyor's system can be fraught with errors (and mistakes)
- "Localization," "calibration," "transformation" add problems of their own
- GIGO!

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The Fancier It Gets, the Harder It Is

- When a steel tape breaks, you know about it, and how to respond to it
- When your EDM, total station, GPS, LiDAR, drone, etc. malfunctions, how to detect?
- What to do about it?
- Black box technology requires more, not less, knowledge about the technology, how it works and how to defend against erroneous or spurious data

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58

Thank You!

- Questions: joepaiva@geo-learn.com

59

About seminar presenter Joseph V.R. Paiva

Dr. Joseph V.R. Paiva, is principal and CEO of GeoLearn, LLC (www.geo-learn.com), an online provider of professional and technician education since February 2014. He also works as a consultant to lawyers, surveyors and engineers, and international developers, manufacturers and distributors of instrumentation and other geomatics tools, as well being a writer and speaker. One of his previous roles was COO at Gatewing NV, a Belgian manufacturer of unmanned aerial systems (UAS) for surveying and mapping during 2010-2012. Trimble acquired Gatewing in 2012. Because of this interest in drones, Joe is an FAA-licensed Remote Pilot.

Selected previous positions Joe has held includes: managing director of Spatial Data Research, Inc., a GIS data collection, compilation and software development company; senior scientist and technical advisor for Land Survey research & development, VP of the Land Survey group, and director of business development for the Engineering and Construction Division of Trimble; vice president and a founder of Sokkia Technology, Inc., guiding development of GPS- and software-based products for surveying, mapping, measurement and positioning. Other positions include senior technical management positions in The Lietz Co. and Sokkia Co. Ltd., assistant professor of civil engineering at the University of Missouri-Columbia, and partner in a surveying/civil engineering consulting firm.

Joe has continued his interest in teaching by serving as an adjunct instructor of online credit and non-credit courses at the State Technical College of Missouri, Texas A&M University-Corpus Christi and the Missouri University of Science and Technology. His key contributions in the development field are: design of software flow for the SDR2 and SDR20 series of Electronic Field Books, project manager and software design of the SDR33, and software interface design for the Trimble TTS500 total station.

He is a Registered Professional Engineer and Professional Land Surveyor, was an NSPS representative to ABET serving as a program evaluator, where he previously served as team chair, and commissioner, and has more than 30 years experience working in civil engineering, surveying and mapping. Joe writes for *POB*, *The Empire State Surveyor* and many other publications and has been a past contributor of columns to *Civil Engineering News*. He has published dozens of articles and papers and has presented over 150 seminars, workshops, papers, and talks in panel discussions, including authoring the positioning component of the Surveying Body of Knowledge published in *Surveying and Land Information Science*. Joe has B.S., M.S. and PhD degrees in Civil Engineering from the University of Missouri-Columbia. Joe's past volunteer professional responsibilities have included president of the Surveying and Geomatics Educators Society (SaGES) 2017-19 and various *ad hoc* and organized committees of NSPS, the Missouri Society of Professional Surveyors, ASCE and other groups.

GeoLearn is the online learning portal provider for the Missouri Society of Professional Surveyors, and surveying professional societies in Kansas, New York, Texas, Pennsylvania, Wisconsin, Arizona and Oklahoma. More organizations are set to partner with GeoLearn soon.

Dr. Paiva can be reached at joepaiva@geo-learn.com or on Skype at joseph_paiva.

Apr 2021

Structural Deformation Monitoring Technology- Concepts, System Planning and Hardware

William T. Derry, Prof. LS

Solutions, Structural Monitoring

Agenda

- Introduction/Bio
- Why/What/How
- Campaign or Permanent?
- General Considerations for projects
- Questions-General Discussion
- Overview of recent projects
- Questions-General Discussion
- Monitoring Hardware
  - Instruments- ATR, Imaging, reflectorless, Scanning
  - GNSS- RTK and Static
  - Geotechnical Sensors
- Monitoring Software-
  - GeoMoS Monitor, Analyzer, Adjustment
  - GeoMoS Now!
  - GeoMonitoring Hub
- Questions-General Discussion

Who I am:

William T. Derry, Prof. LS

- Licensed in PA, DE, MD and NC
- 38 years experience, with 24 as licensee
- Formally trained as a geodetic surveyor in the USMC prior to the common availability of GPS (1984)
- Background in GNSS control, boundaries, ALTAs, structural layout, topo
- Wild Heerbrugg/Wild Leica/Leica Geosystems user since 1984 (T2, T3 etc.)
- Started with Leica as a Technical Sales Engineer in June 2018
- Solutions Team, Structural Monitoring
- Technical support and installations, Sales Support in US, Canada, Mexico

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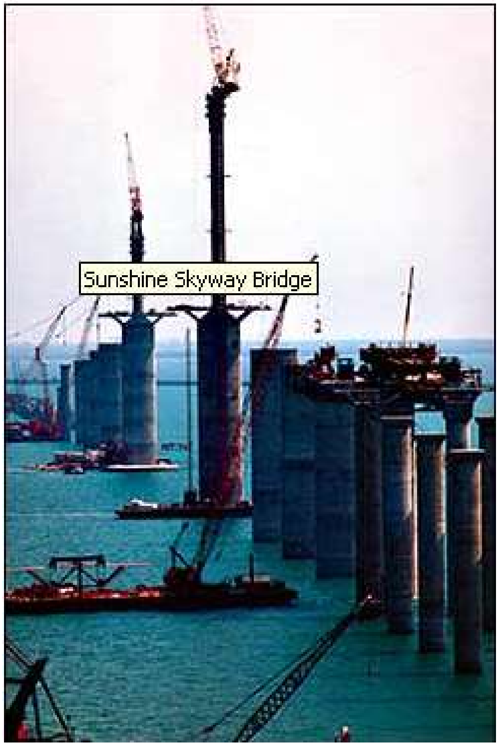
Please Ask Questions

In Monitoring, the question is-

Did it move, yes or no?

We know structures move so the questions really are-

- When?
- Where and What?
- Why?
- How much?
- What is the impact?
- How do I know if it is local “resonation” and environmentally induced?
- Did it move back?
- ???



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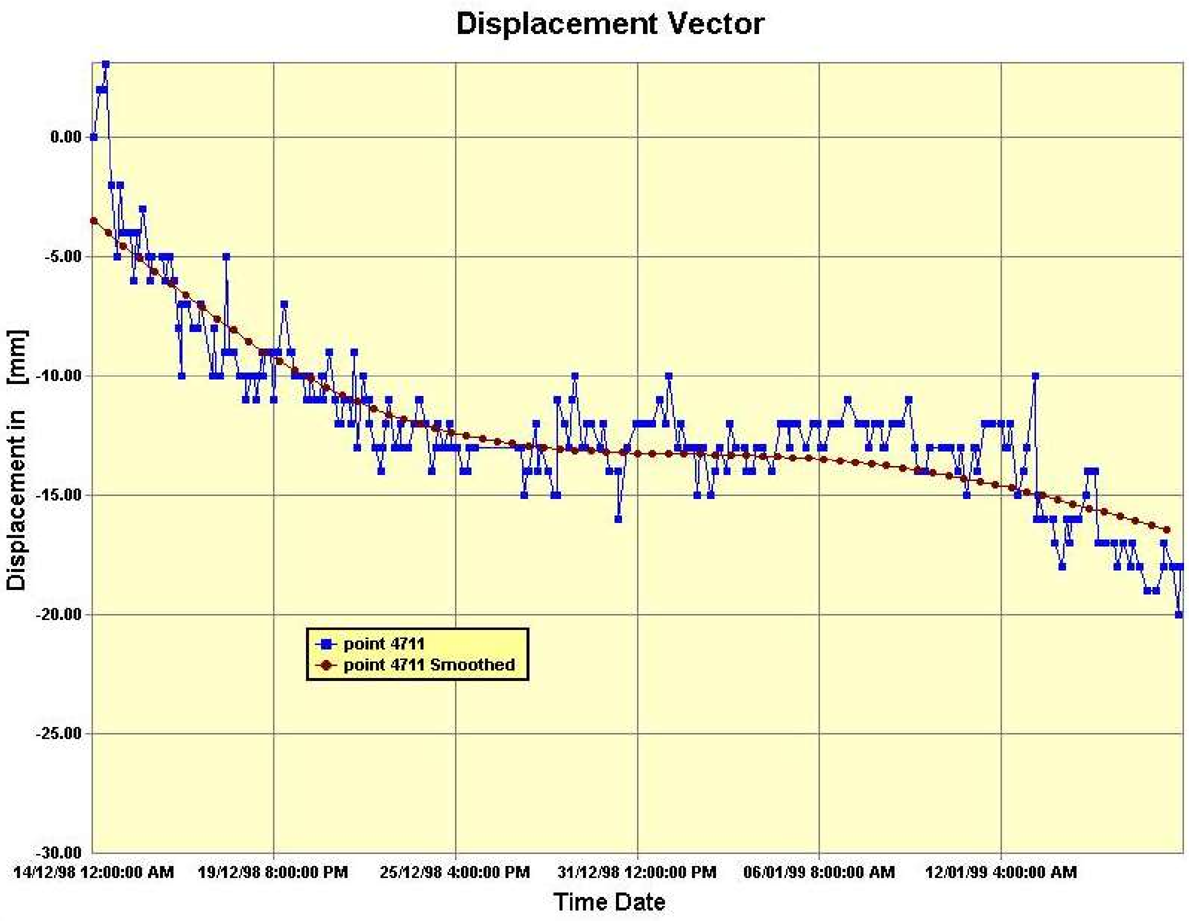
What can be monitored

- Manmade objects
  - Bridges/Dams/Buildings/Walls
  - Tunnels/Aqueducts/Railroads/Highways
  - Excavations/Slopes/Mines/Reserve Structures
  - Clearances/Moving Components/Ships
  - Core Wall (Super tall etc.)
- Natural Objects
  - Landslides/Avalanches/Volcanos/Embankments
  - Tectonic Motion

Why we Monitor

Safety
- Protect Life
- Protect Assets

Quality
- Site Supervision
- Better Serviceability
- Reduce Project Interruptions Liability
- Defend against Construction Defects Litigation
  - Design Errors
  - Environmental Damages
  - Insurance & Bonding



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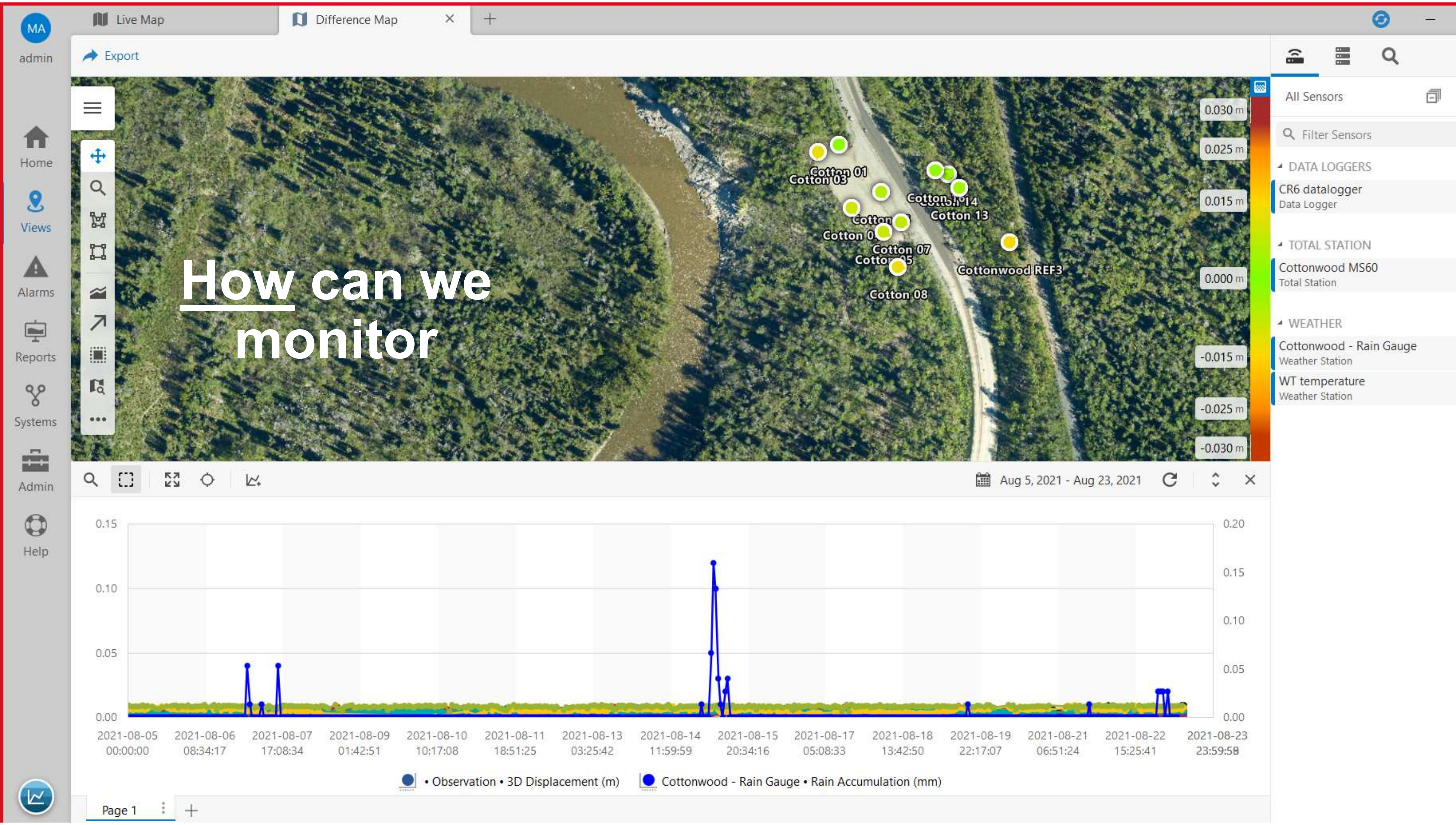
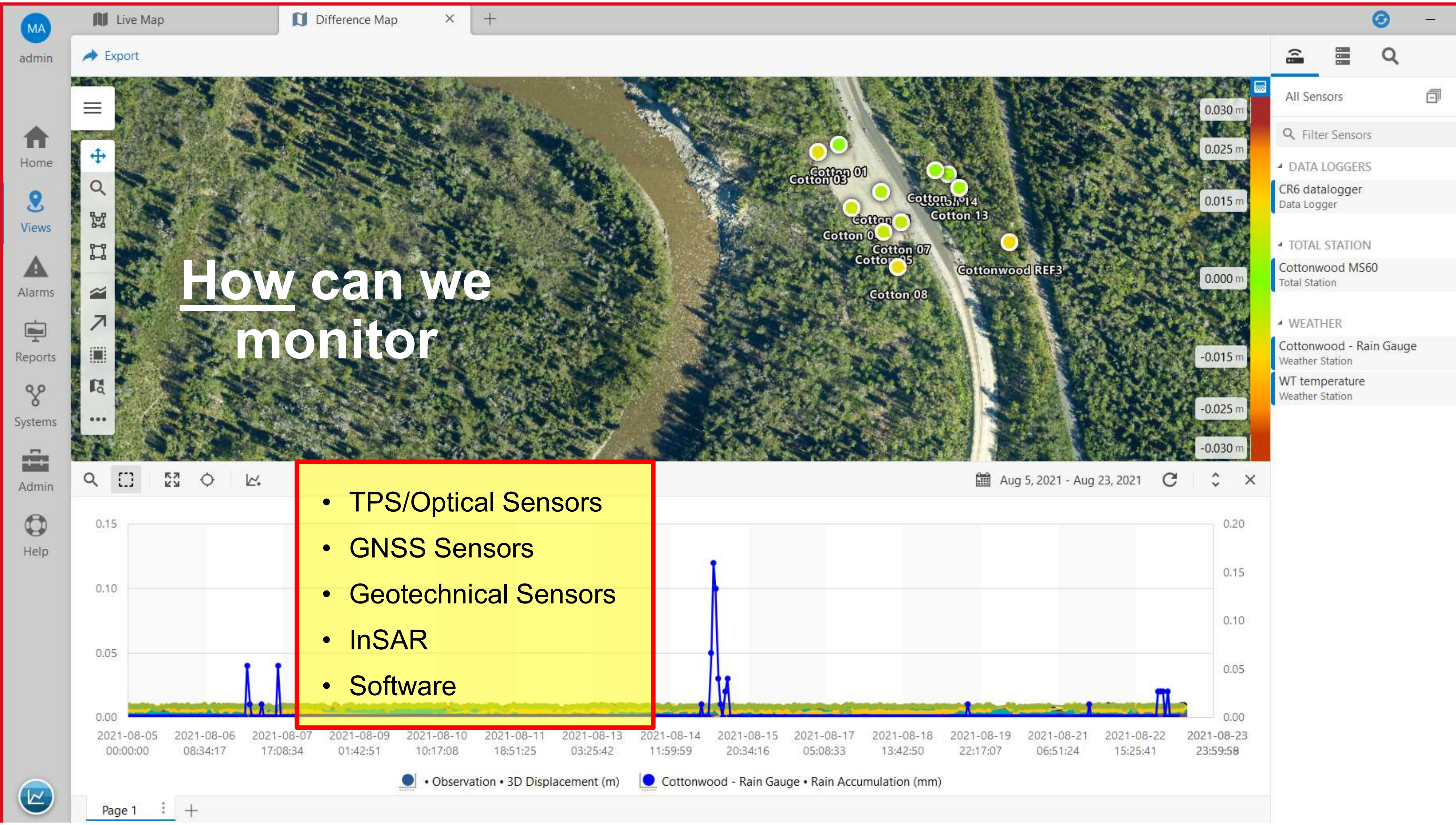
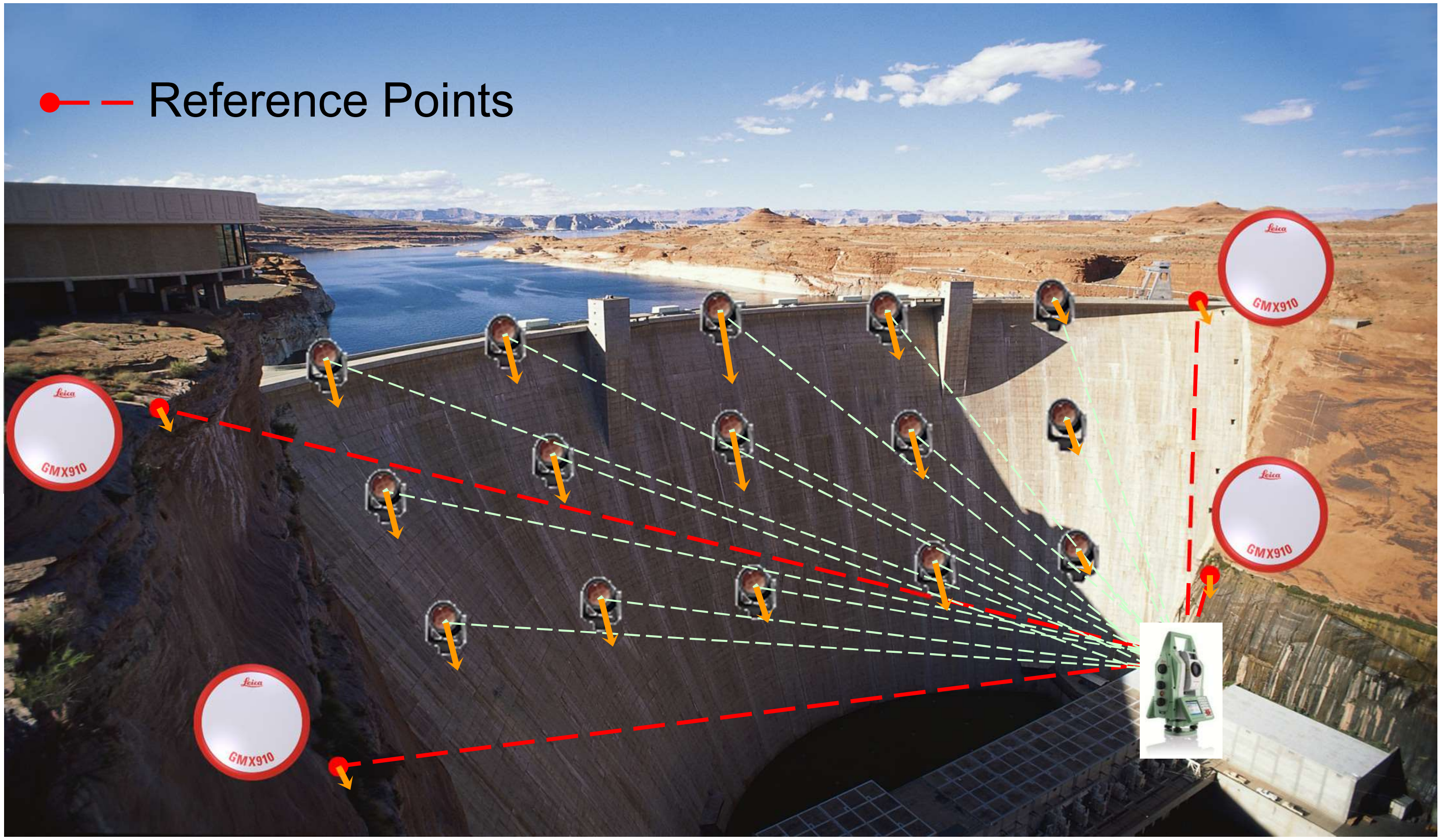

How can we monitor
Live Map
Difference Map
admin
Export
Home
Views
Alarms
Reports
Systems
Admin
Help
All Sensors
Filter Sensors
DATA LOGGERS
CR6 datalogger
Data Logger
TOTAL STATION
Cottonwood MS60
Total Station
WEATHER
Cottonwood - Rain Gauge
Weather Station
WT temperature
Weather Station
Cotton 01
Cotton 03
Cotton 13
Cotton 07
Cotton 08
Cottonwood REF3
Aug 5, 2021 - Aug 23, 2021
• Observation • 3D Displacement (m)
Cottonwood - Rain Gauge • Rain Accumulation (mm)
Page 1

How can we monitor

- TPS/Optical Sensors
- GNSS Sensors
- Geotechnical Sensors
- InSAR
- Software



Typical TPS/GNSS Monitoring Scheme



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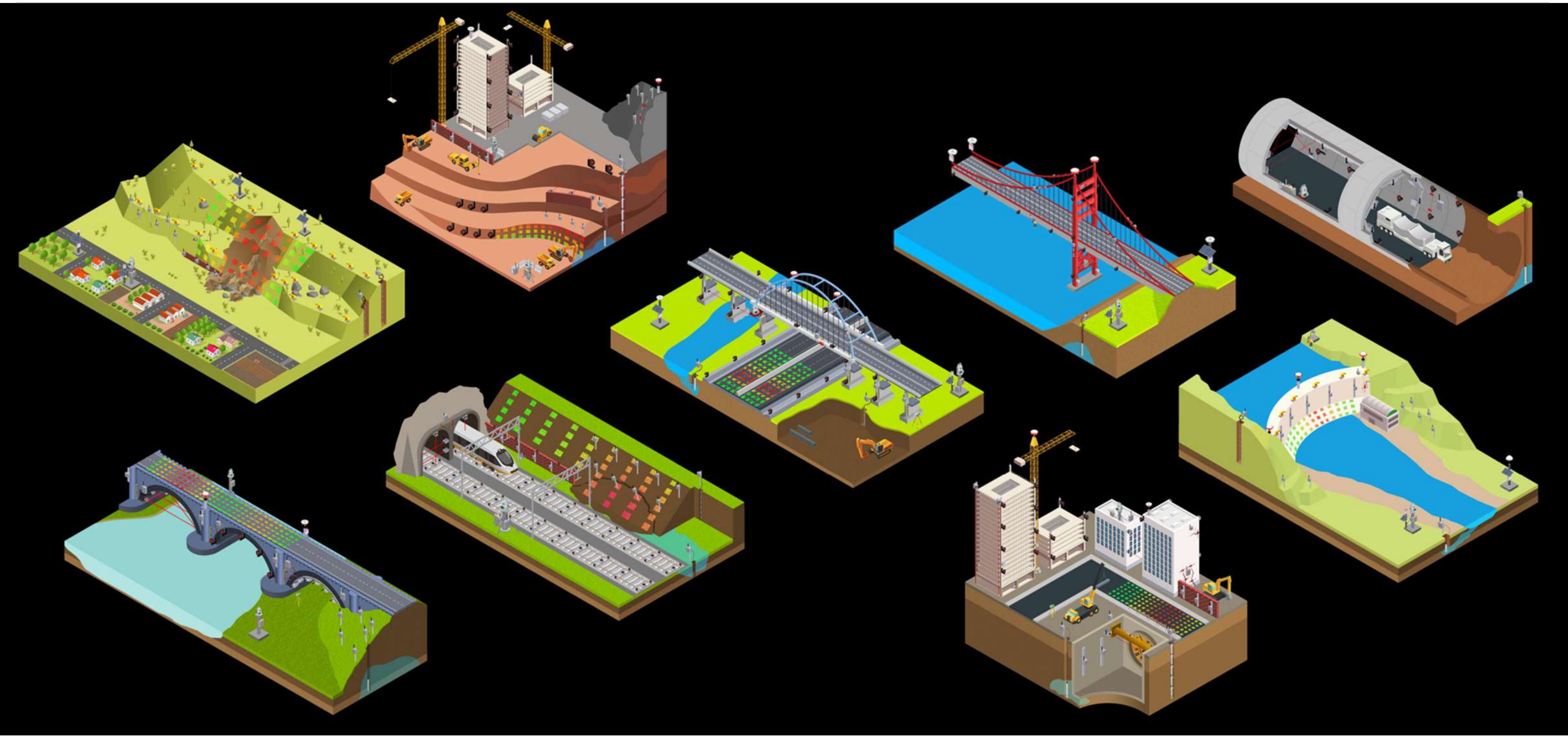
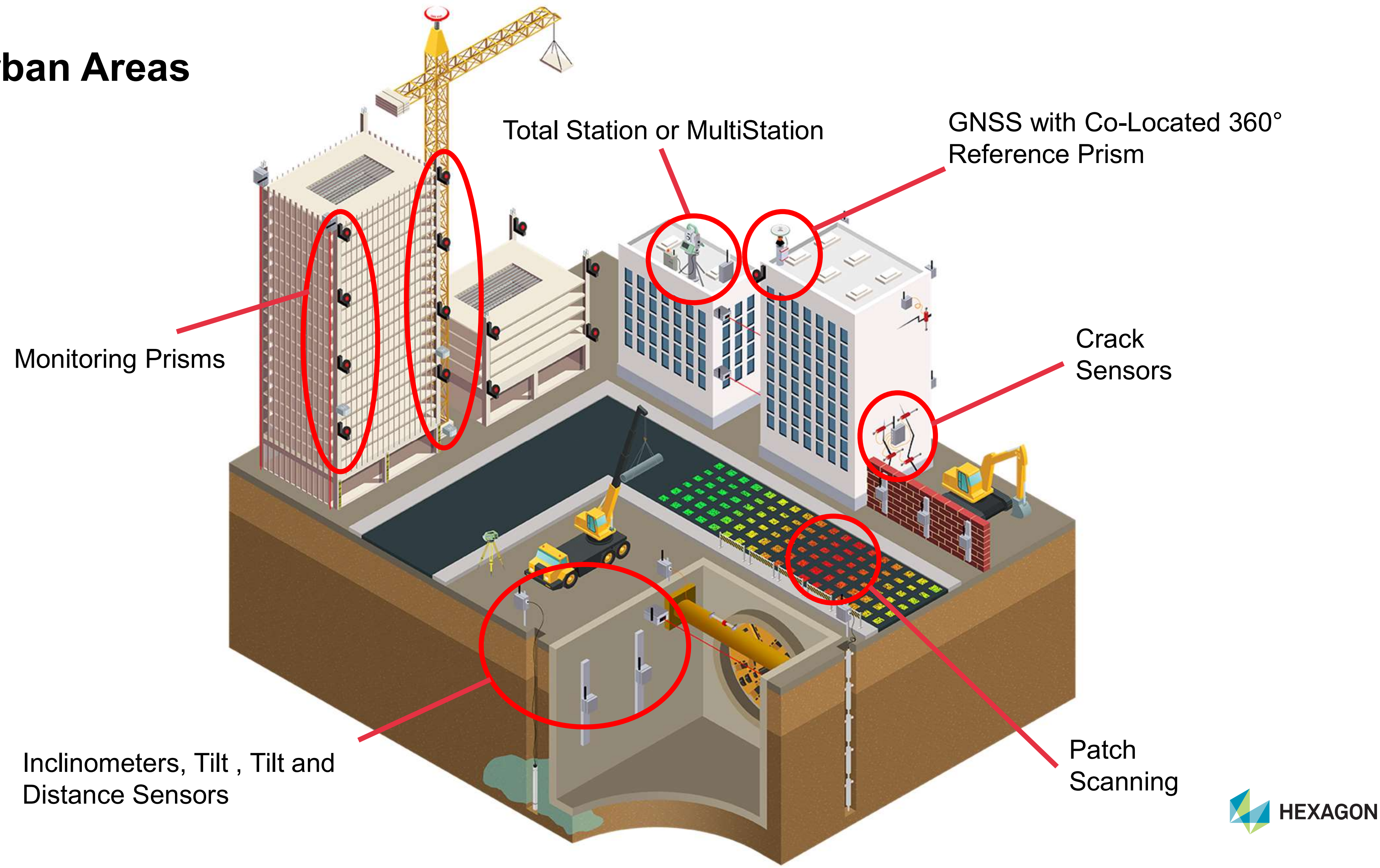
Monitoring Scenario Exploration



Urban Areas


Total Station or MultiStation
GNSS with Co-Located 360°
Reference Prism
Monitoring Prisms
Crack
Sensors
Inclinometers, Tilt , Tilt and
Distance Sensors
Patch
Scanning
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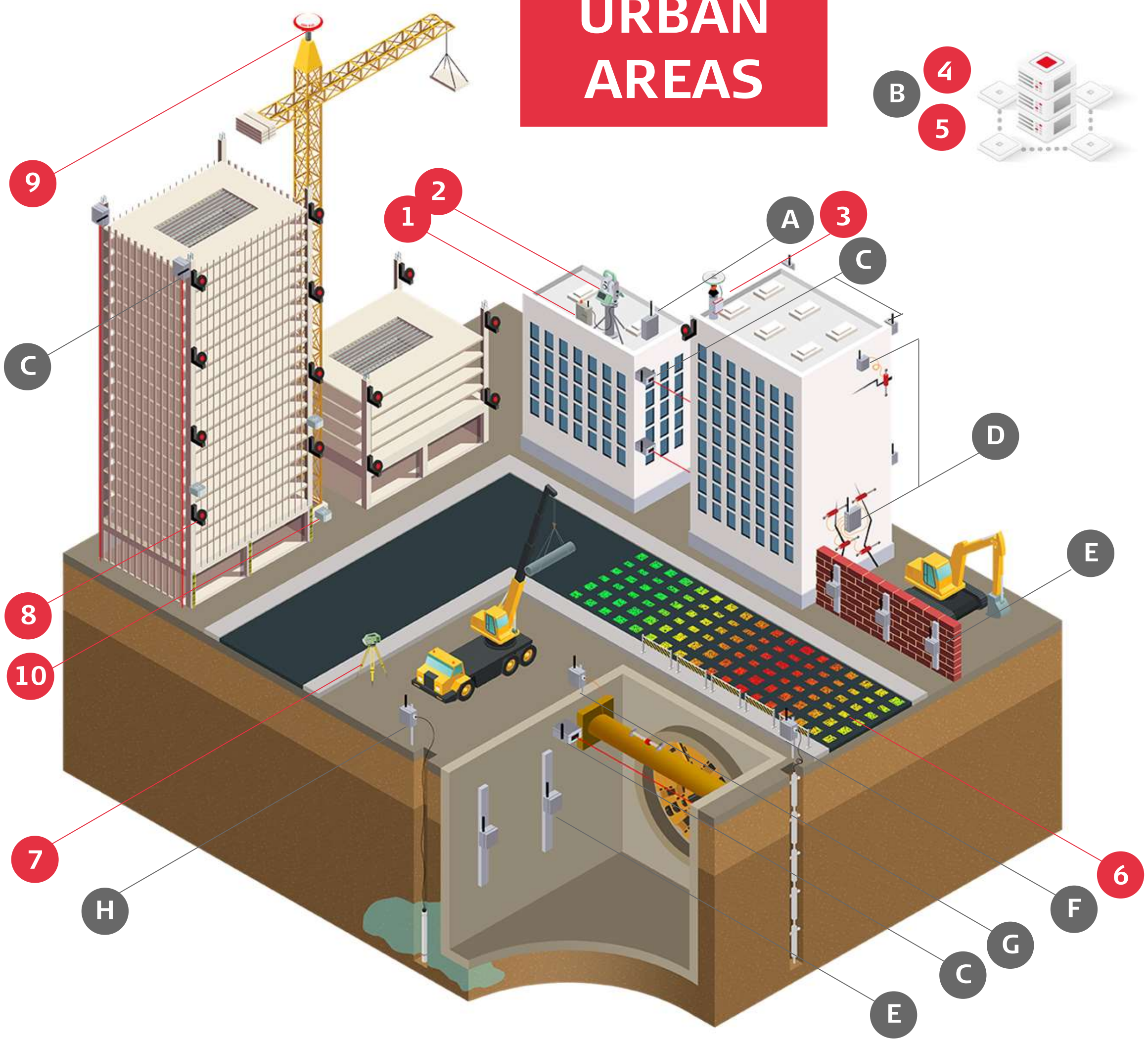
URBAN AREAS



1 Leica M-Com communication & power solution

2 Leica Nova TM60 Total Station I or MS60 MultiStation for 3D measurement, images and scanning

3 Leica AS11 / GM30 GNSS with co-located 360° reference prism

4 Leica GeoMoS Monitor data acquisition & computation software

5 Leica GeoMoS Now! data analysis & visualisation software / service

6 Leica MS60 observations of vertical settlement by scanning

7 Leica LS15 precise digital level used as part of manual campaign monitoring barcode targets on the buildings for precise detection of settlement

8 Leica GMP104 monitoring prisms used for precise 3D structural Monitoring of buildings. Compression, alignment, rotation & tilt displacements

9 Leica GNSS receiver GMX910 tracking crane position

10 Leica NIVEL 220 ultra-precision inclinometer to measure crane foundation tilt

A Wireless sensor network smart data hub

B Wireless data import into Leica Geosystems GeoMoS via AnyData

C Wireless sensor distance & tilt measurement for convergence/compression

D Wireless interface sensor with locally connected crack gauges

E Wireless tilt sensors with beam to measure inclination of objects

F Wireless interface sensor with locally connected in-place inclinometer

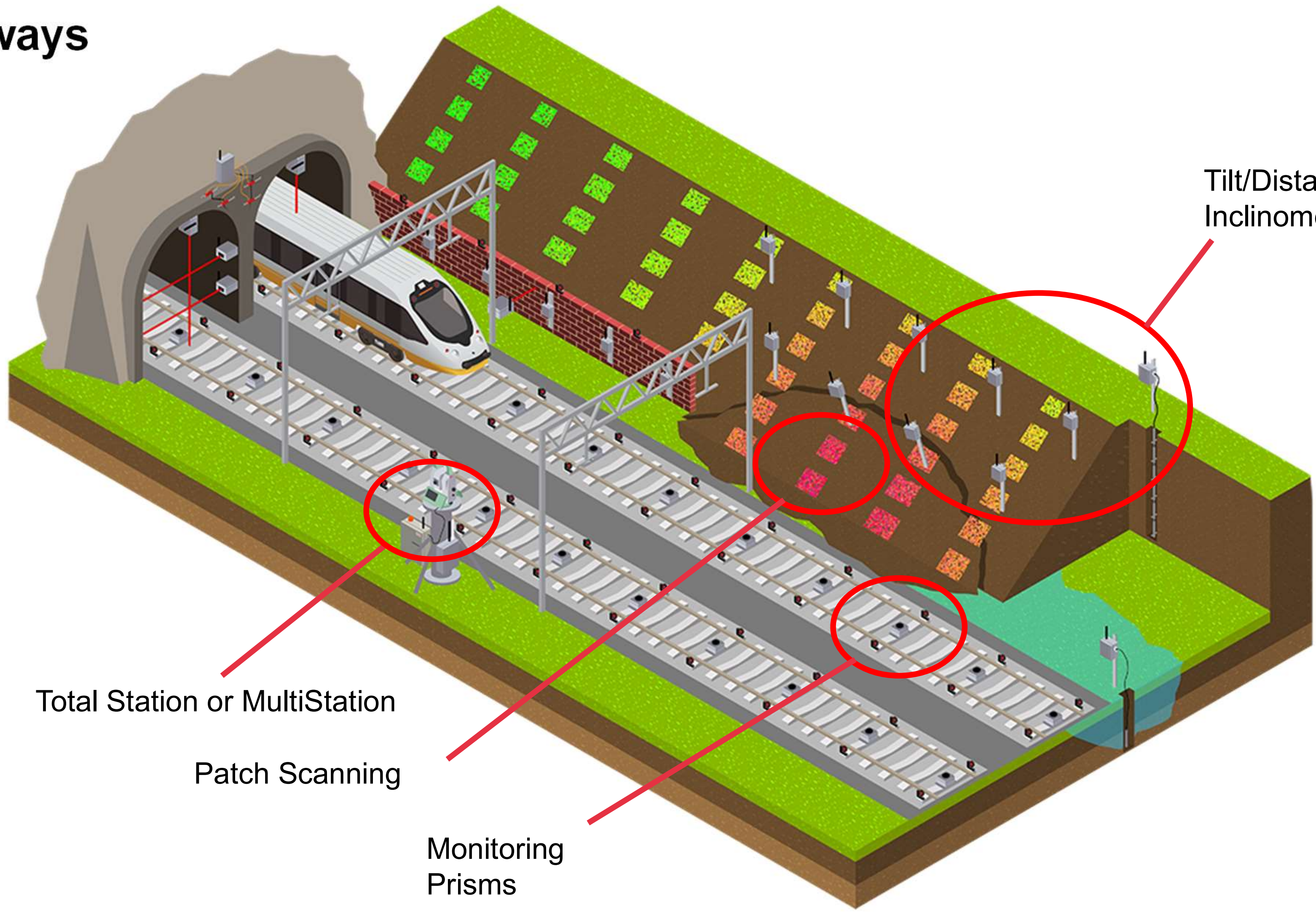
G Wireless interface sensor with locally connected strain gauge

H Wireless interface sensor with locally connected water level gauge

- when it has to be right

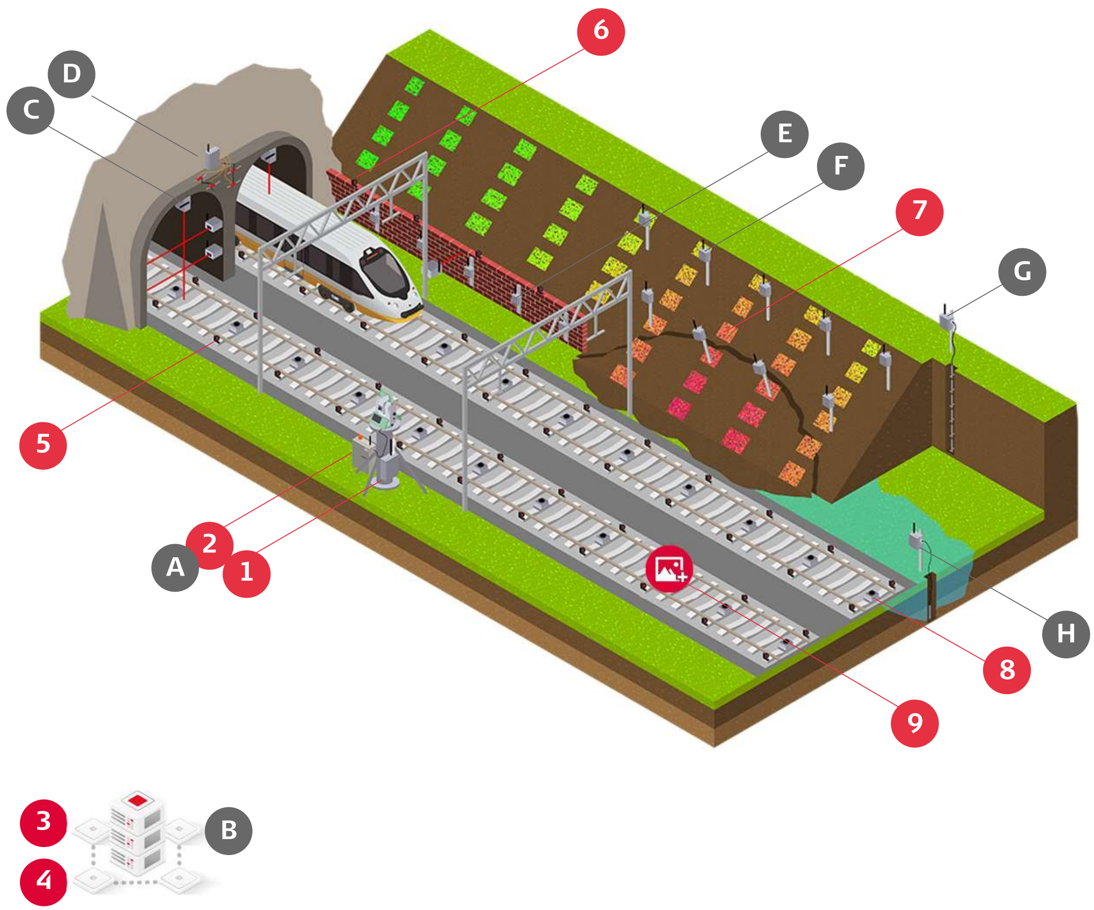
Leica Geosystems

Railways



Tilt/Distance,
Inclinometers
Total Station or MultiStation
Patch Scanning
Monitoring
Prisms

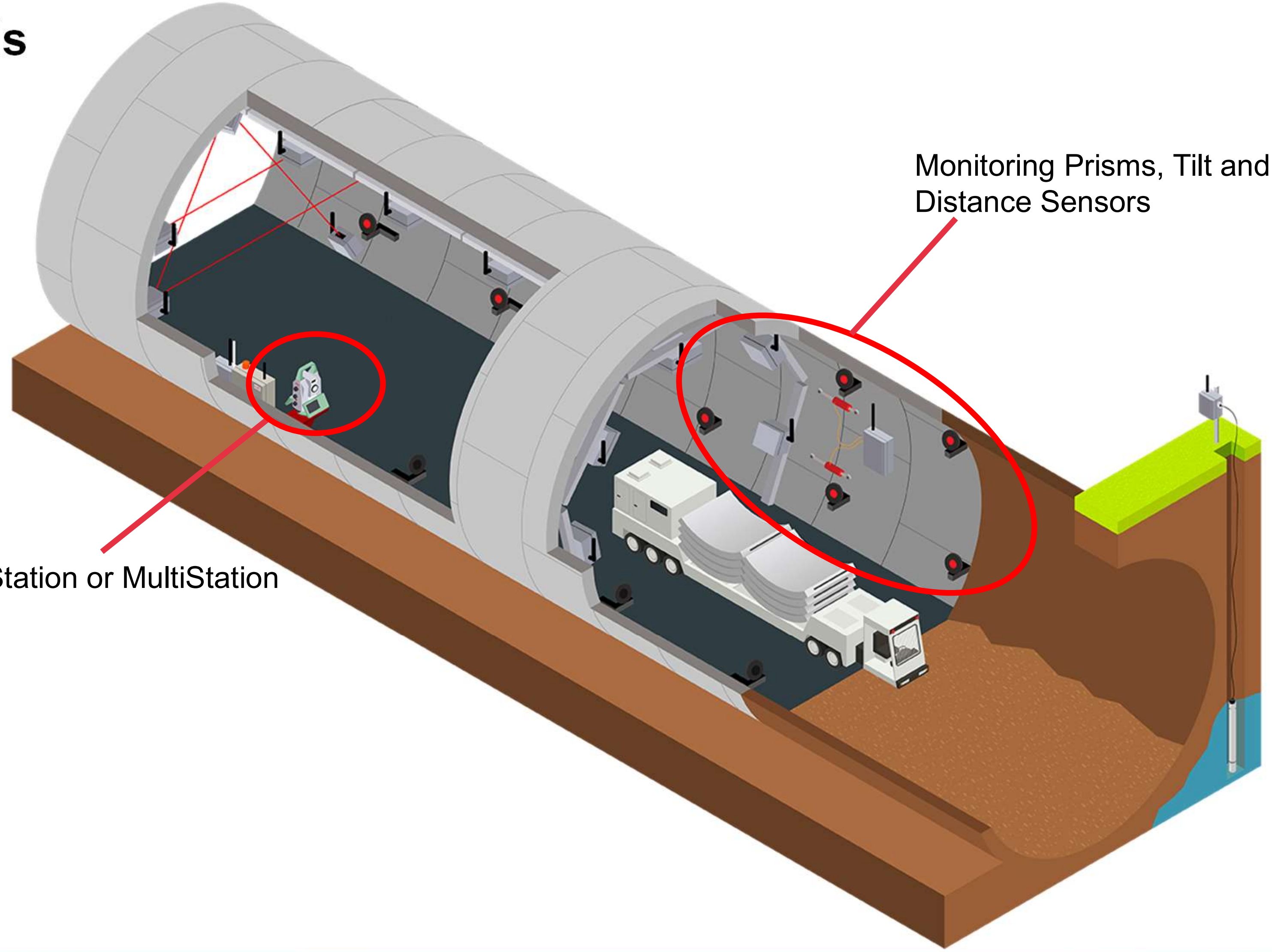
RAILWAY



1. Leica TM60 I or MS60 total station for 3D measurement, imaging and scanning
2. Leica Communication & Power enclosure with Leica M-Com
3. Leica GeoMoS Monitor data acquisition & computation software
4. Leica GeoMoS Now! data analysis & visualisation software / service
5. Leica GMP104 Prisms measuring 3D absolute track geometry
6. Leica GMP104 Prisms measuring absolute 3D structure position
7. Remote detection of slope failure using fully automated 3D laser patch scanning technology via GeoMoS and MS60
8. Automated track geometry changes computed and alarmed via GeoMoS
9. Remote image capture / live video stream of embankment via TPS telescope camera

- A Wireless smart data hub for geotechnical sensors
- B Geotechnical sensor data import into Leica GeoMoS via AnyData
- C Wireless sensor distance & tilt measurement for convergence/compression
- D Wireless interface with locally connected crack gauges
- E Wireless sensor distance & tilt measurement for clearance /offset and verticality of trackside wall
- F Wireless tilt sensors to monitor landslide installed with ground anchors
- G Wireless interface with locally connected In Place Inclinometer
- H Wireless interface with locally connected water level gauge

Tunnels



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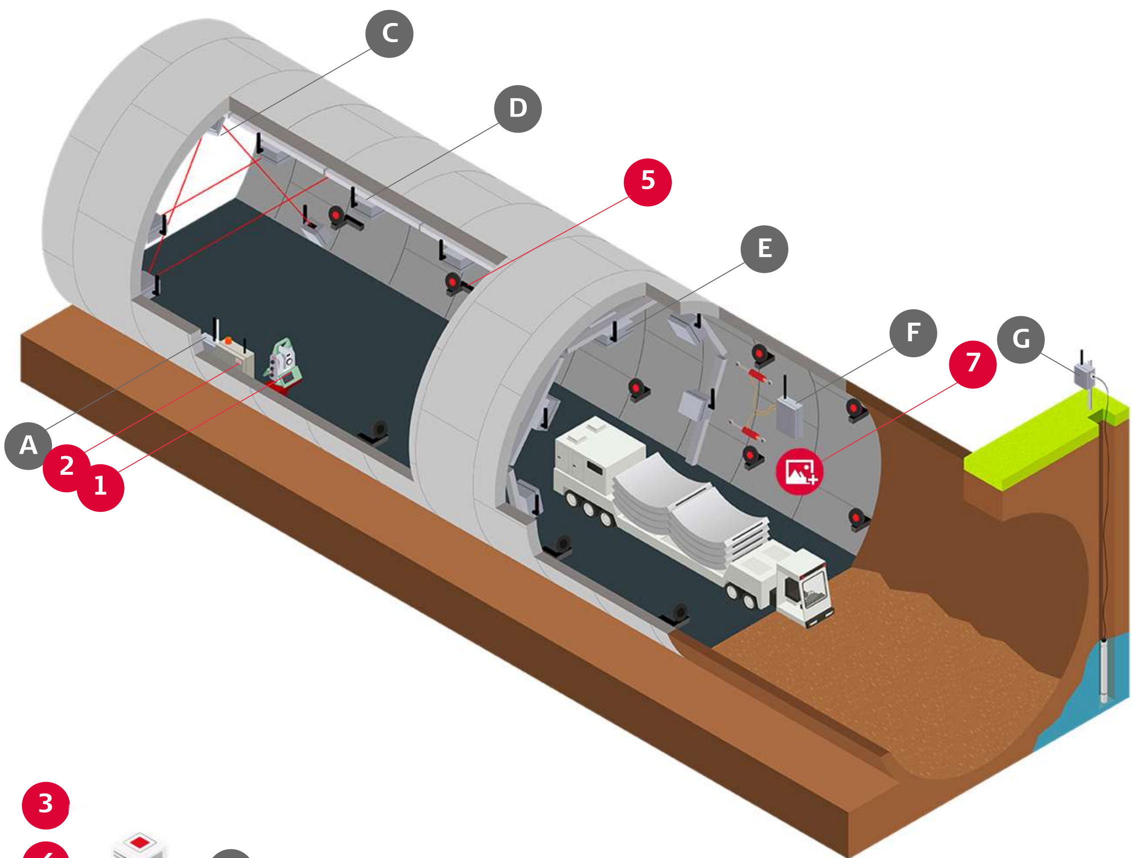
TUNNELS



1. Leica TM/TS/MS60 I total station for 3D measurement & imaging
2. Leica Communication & Power enclosure with Leica M-Com
3. Leica GeoMoS Monitor data acquisition & computation software
4. Leica GeoMoS Now! data visualisation software / service
5. Leica GMP104 Prisms measuring absolute 3D structure position
6. 3D geometry computations for tunnel convergence and longitudinal profile completed in GeoMoS Monitor using prism data and AnyData Import
7. Remote image capture / live video of construction site via TPS telescope camera

- A Wireless smart data hub for geotechnical sensors
- B Geotechnical sensor data import into Leica GeoMoS via AnyData
- C Wireless sensor distance & tilt measurement for convergence/compression
- D Wireless sensor tilt with beam measurement for longitudinal profile settlement
- E Wireless sensor tilt with beam measurement for ovalisation measurement
- F Wireless interface with locally connected crack gauges
- G Wireless interface with locally connected water level sensor / in-place inclinometer

- when it has to be **right**

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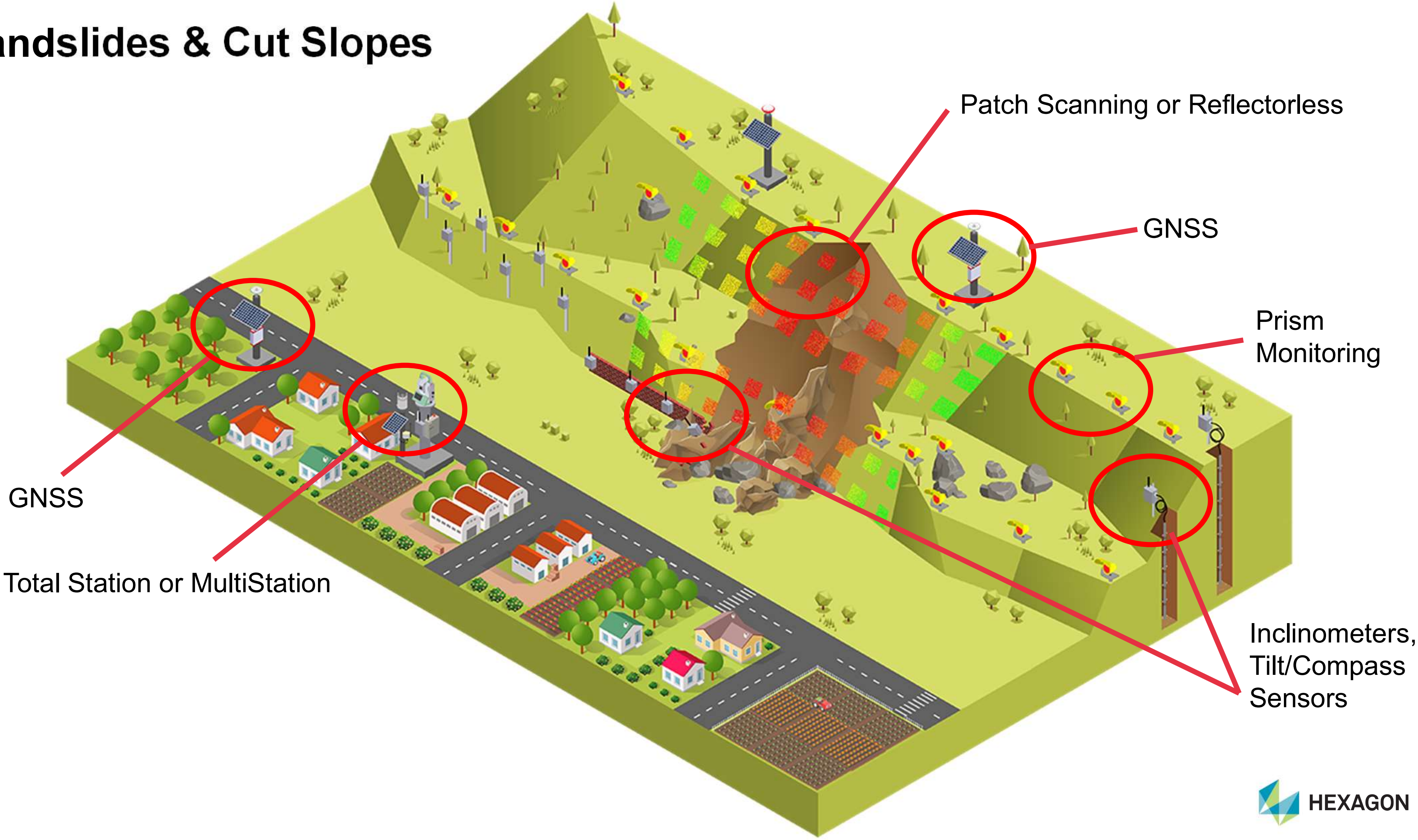
Landslides & Cut Slopes



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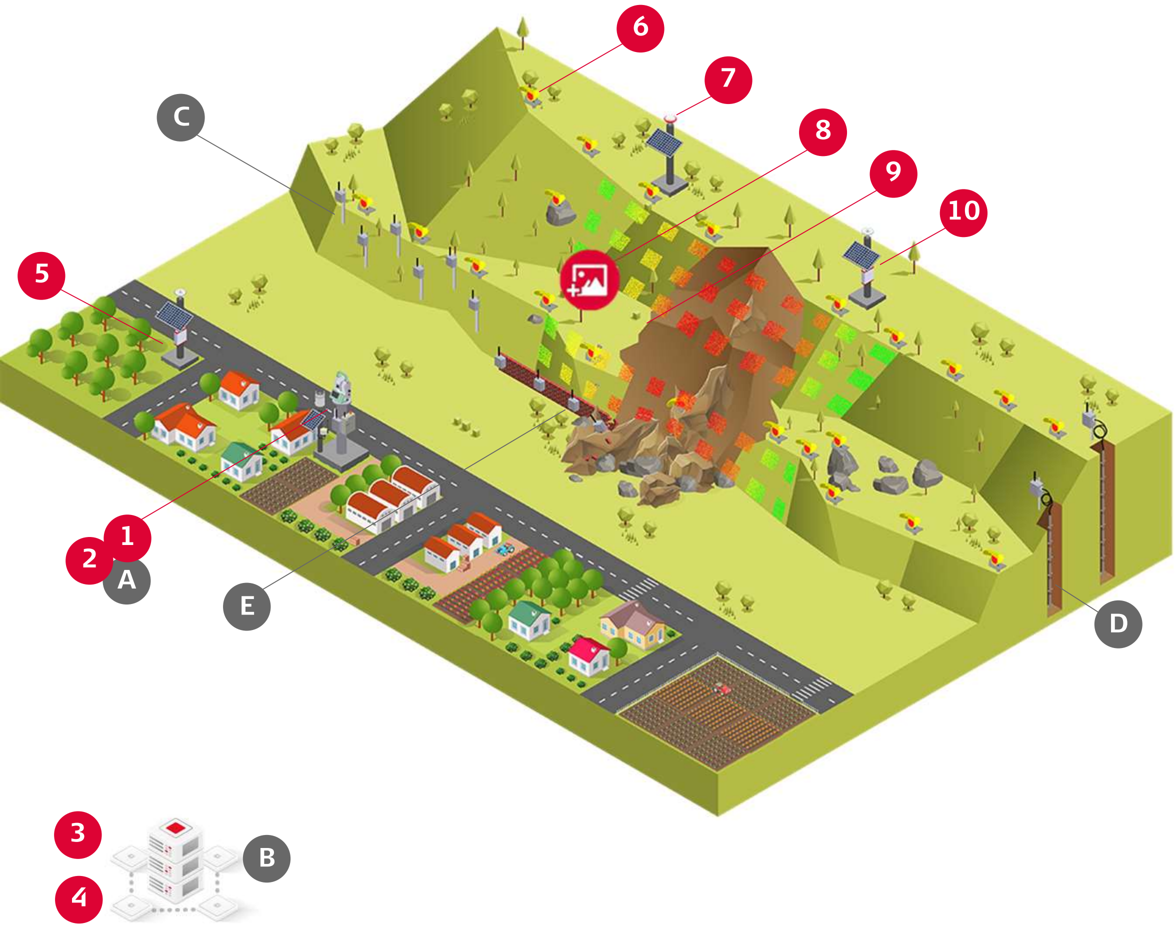
LANDSLIDES & CUT SLOPES



1. Leica MS60 MultiStation for 3D measurement, imaging & scanning
2. Leica Communication & Power enclosure with Leica M-Com
3. Leica GeoMoS Monitor data acquisition & computation software
4. Leica GeoMoS Now! data analysis & visualisation software / service
5. Leica Geosystems AS10 / GM30 GNSS absolute 3D monitoring
6. Leica GPR112 monitoring prisms measuring 3D structural displacements
7. Leica GMX910 smart antenna tracking position via post-processing & GNSS Spider
8. Remote image capture / live video stream of embankment via TPS telescope camera
9. Remote detection of surface deformation using fully automated 3D laser patch scanning technology via MS60 and GeoMoS
10. Leica VADASE for rapid autonomous GNSS displacement onboard GM30

- A — Wireless smart data hub for geotechnical sensors
- B — Geotechnical sensor data import into Leica GeoMoS via AnyData
- C — Wireless tilt sensors to monitor slope
- D — Wireless interface with locally connected water level sensor / IPI / borehole extensometers
- E — Wireless sensor tilt measurement for verticality of wall

- when it has to be **right**

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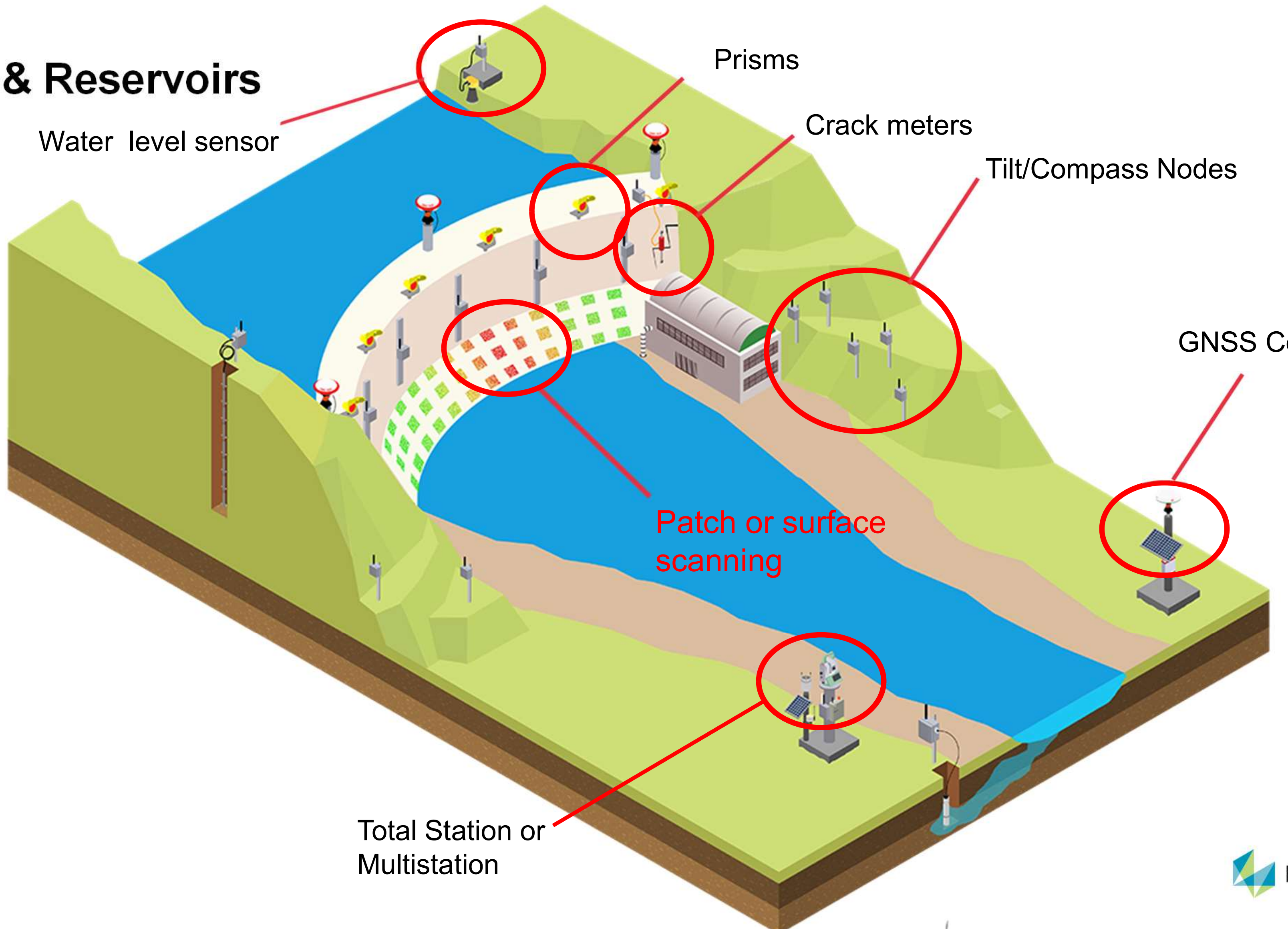
Dams & Reservoirs



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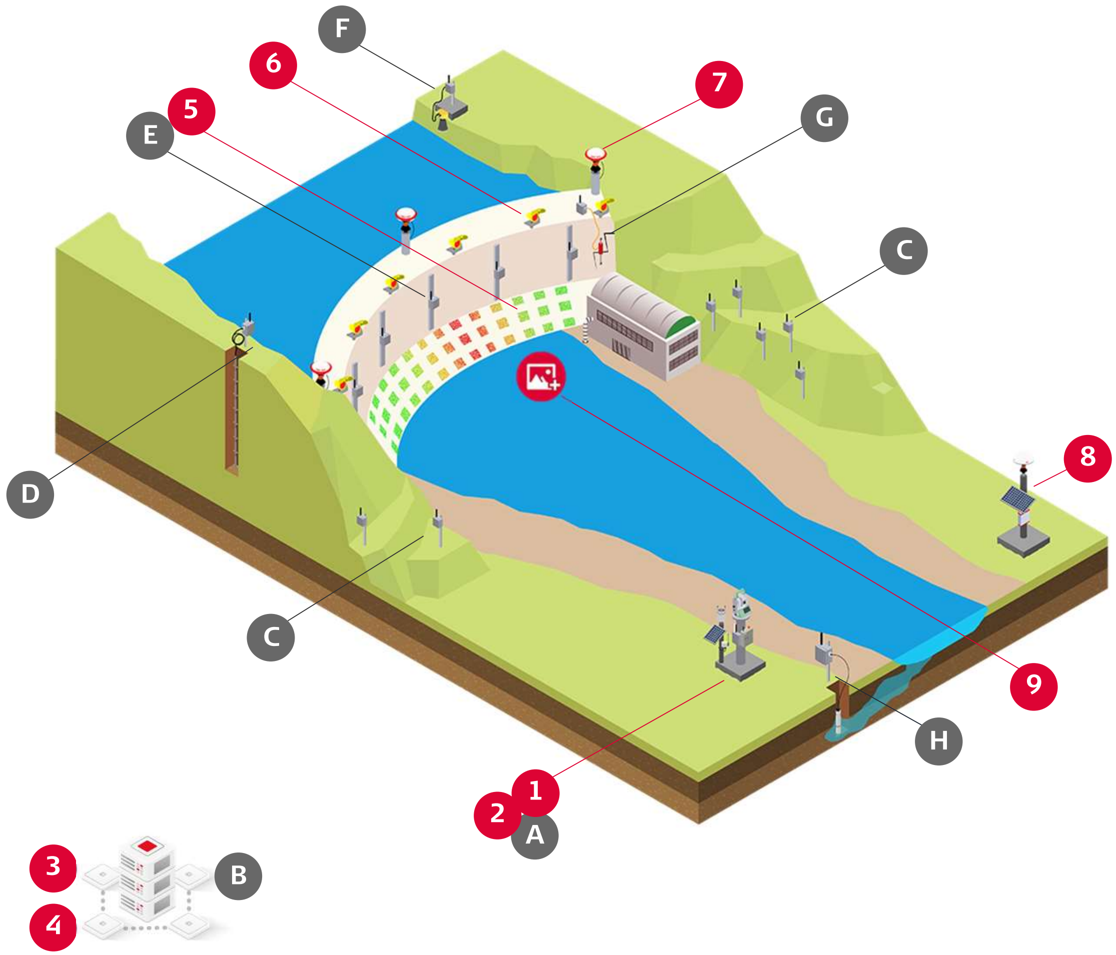
DAM & RESERVOIR



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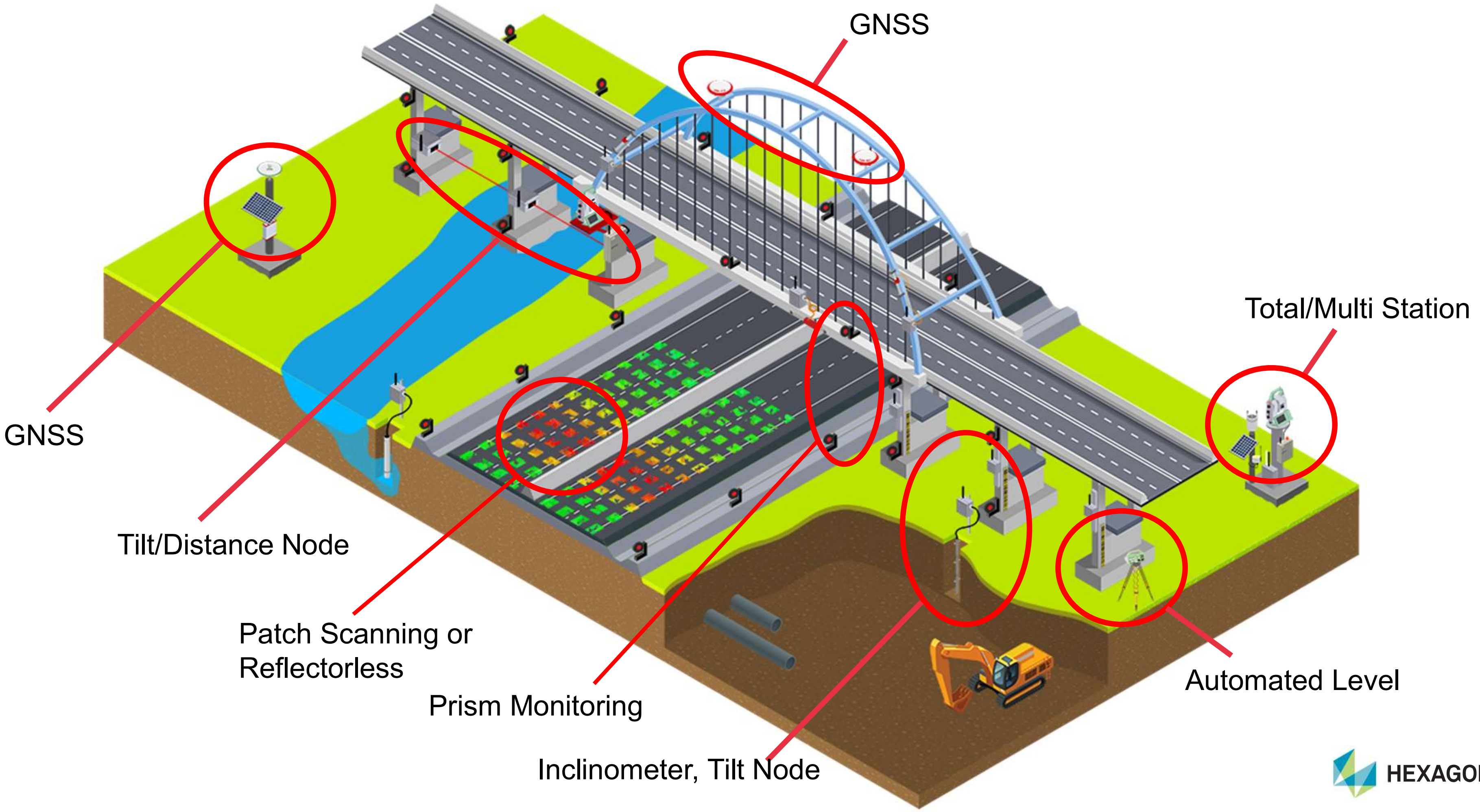
4. Leica GeoMoS Now! data analysis & visualisation software / service
5. Remote detection of surface deformation using fully automated 3D laser patch scanning technology via MS60 and GeoMoS
6. Leica GPR112 monitoring prisms measuring 3D structural displacements
7. Leica GMX910 GNSS 3D monitoring, with co-located 360° prism for use with survey control and network adjustment software
8. Leica AR10 antenna with GM30 GNSS reference station with co-located 360° prism and Leica CrossCheck service monitoring the stability of the reference point
9. Remote image capture / live video stream of structure via TPS telescope camera
10. Remote detection of surface deformation using fully automated 3D laser patch scanning technology via MS60 and GeoMoS

- A Wireless smart data hub for geotechnical sensors
- B Geotechnical sensor data import into Leica GeoMoS via AnyData
- C Wireless tilt sensors to monitor slope
- D Wireless interface with locally connected In-Place-Inclinometer
- E Wireless sensor distance & tilt measurement for verticality of wall
- F Wireless interface with locally connected sonar/radar water level detector
- G Wireless interface with locally connected crack gauges
- H Wireless interface with locally connected water level piezometer

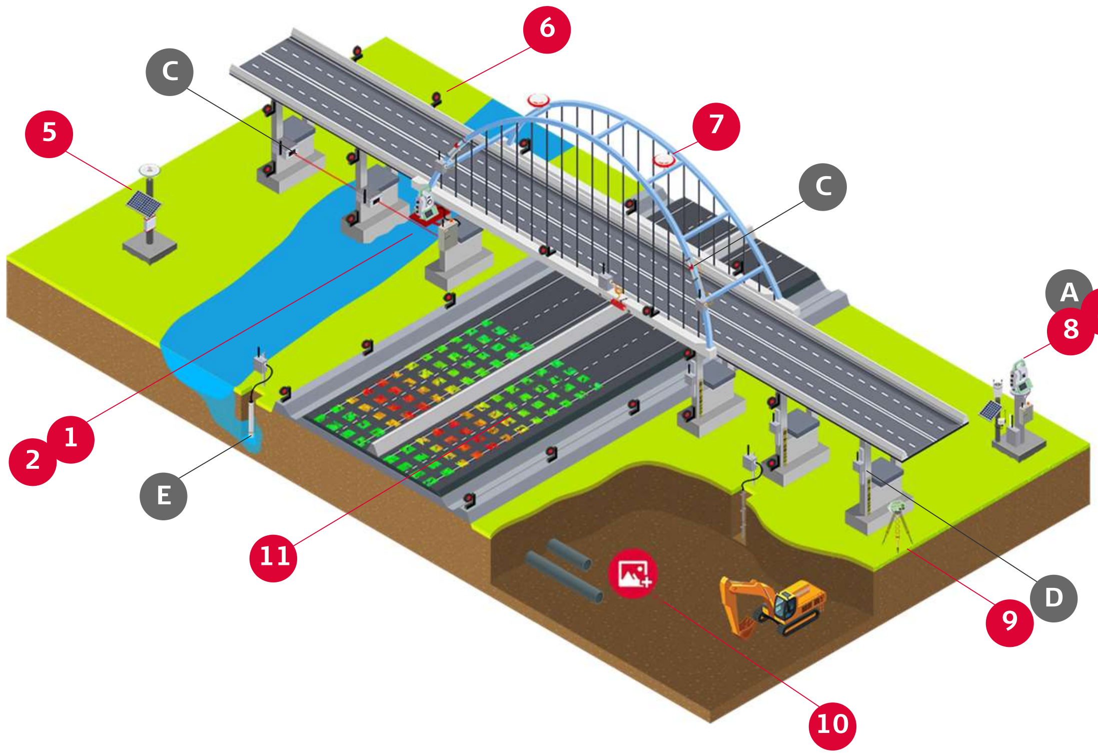
- when it has to be right

Leica Geosystems

Transportation Infrastructure



HIGHWAYS



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5. Leica AS11 / GM30 GNSS absolute 3D monitoring
6. Leica GMP104 prisms measuring absolute 3D structure position
7. Leica GMX910 Smart Antenna for positioning via RTK & Leica GNSS Spider verifying structural deformation / movement
8. Leica TM/TS/MS60 I total station for 3D measurement and imaging
9. Leica LS15 precise digital level used as part of manual campaign monitoring & barcode targets for precise detection of settlement
10. Remote image capture / live video stream of structure via TPS telescope camera
11. Remote detection of surface deformation using fully automated 3D laser patch scanning technology via MS60 and GeoMoS

A. Wireless sensor network smart data hub
B. Wireless data import into Leica GeoMoS via AnyData
C. Wireless interface with locally connected VW strain sensor connected to structure
D. Wireless tilt sensors to monitor structural rotation
E. Wireless interface with locally connected water level sensor

- when it has to be right

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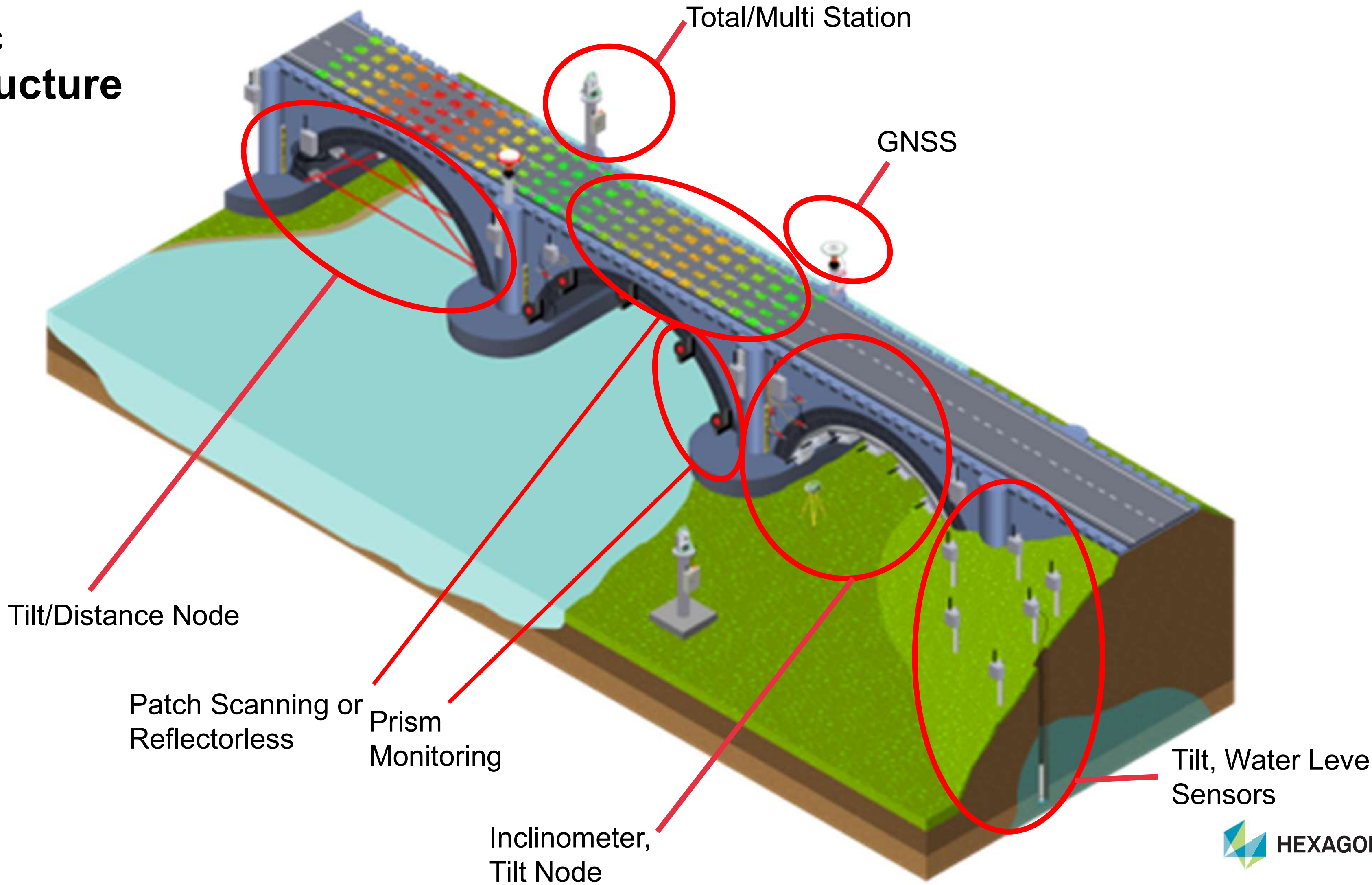
Historic Infrastructure



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QUESTIONS?

Monitoring Solutions

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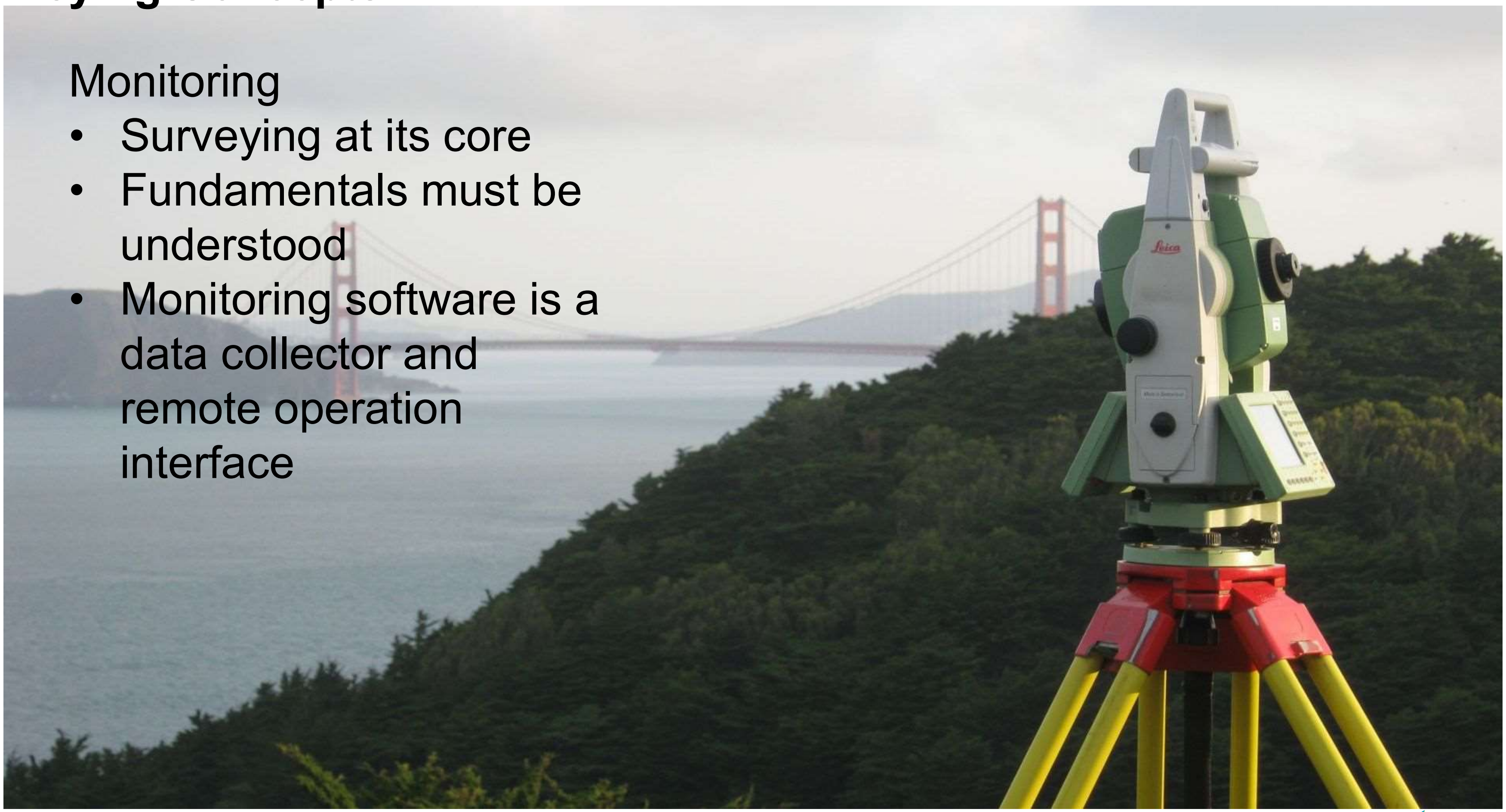
Surveying Concepts



Monitoring

- Surveying at its core
- Fundamentals must be understood
- Monitoring software is a data collector and remote operation interface

Surveying Concepts

Fundamentals

- Trigonometric calculations rule the day
- Basic data is horizontal angle, vertical angle and slope distance
- All calculations use an azimuth to determine geometric positions of objects
- Azimuth is based on orientation to a known point, a.k.a backsight
- The instrument is essentially a highly precise protractor, with an EDM for measuring distances

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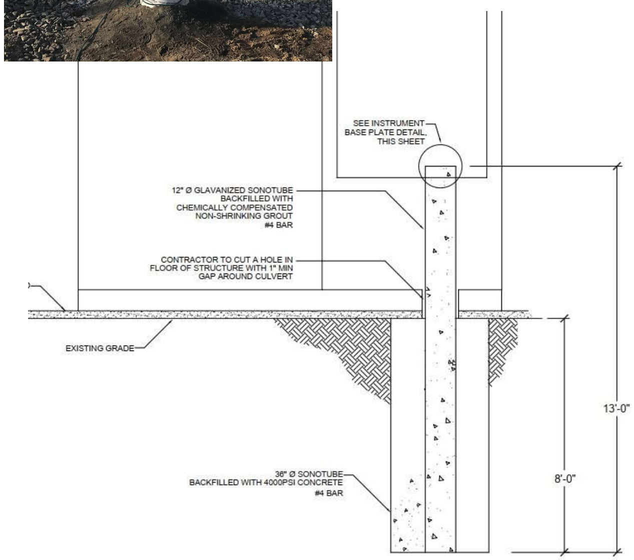
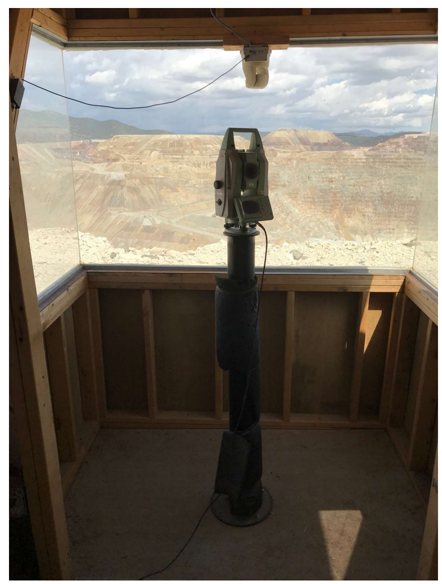
Surveying Concepts

Fundamentals

- Installation
  - Tribrach
  - Pedestal
  - Shack
  - Bracket





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Surveying Concepts

Fundamentals

- Location of instrument
- Communications
- Orientation
- Freestation
- Corrections (Met)

Those two prisms are not the same location????

Surveying Concepts

Fundamentals

- Geometric Concerns
  - Geometric strength of figure
  - Adverse Refraction

- MET Corrections
  - Temperature
  - Pressure
  - EDM only, does not correct optical problems
    - Haze, fog, precipitation
    - Objects, people
    - Terrain

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TPS Monitoring Approach

- Project considerations
  - Duration
  - Timeframe
  - Available assets
  - Infrastructure
  - Specifications
    - Thresholds
    - Frequency
    - Positioning Expectations
    - Specific approach

General Approach Analysis

Campaign or Permanent?

- Positioning requirements
- Schedule and interval
- Duration

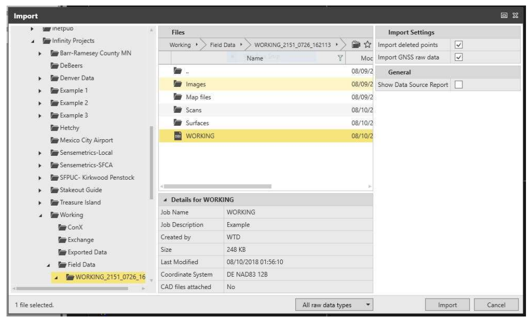
Sensor?

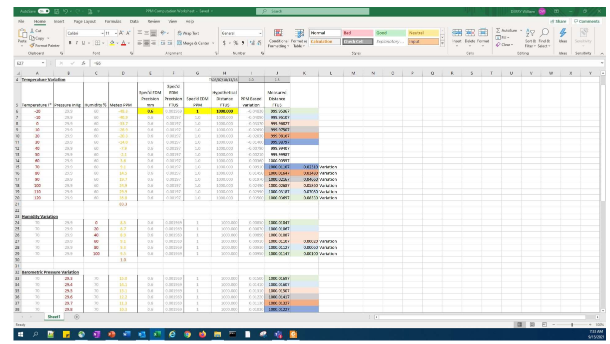
- TPS- Many datapoints
- GNSS- single datapoint
- Geotechnical sensors- datapoint(s) but extended capabilities

Campaign Approach

- Campaign approach is best for:
  - short term projects
  - non-intensive schedules
- Requires very solid procedures for repeatability

Manual Campaign Monitoring





Workflow-

Data collection

Data processing

Excel reporting

Manual Distribution

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Installed Approach

- Installed permanent approach is best for
  - Long term projects - High precision - Continuous monitoring
  - Primary Benefits
    - Automation- Instruments stay in place
    - Dedicated infrastructure = true precision

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Installed Approach

- Considerations
  - Require stable power, communication, mounting
  - Solid planning
  - Requires dedicated computer (desktop or VM)
  - Operational support
    - Office – Field - Maintenance

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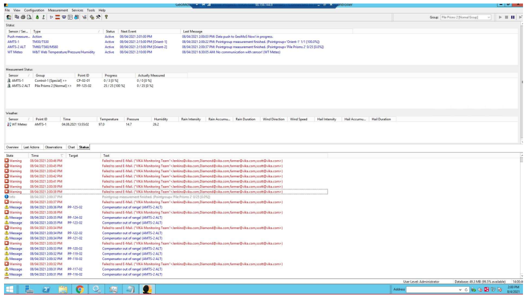
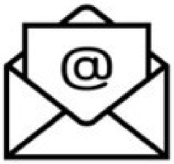
Full Automation Monitoring





Workflow-

Automated data collection
Broader range of sensors
Automated data processing
Realtime updates to client - data and events
Automated distribution and review/analysis/reporting

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Hybrid Approach

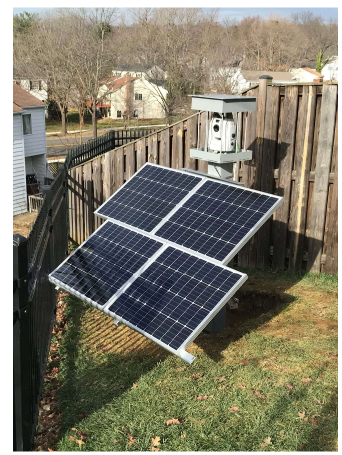
Campaign Monitoring with Automation

Manual Campaign Monitoring

TPS, GNSS, Level etc.
+
Office workflows

Geodetic Monitoring System
(permanent, continuous 24/7 monitoring)

Detailed long term installation with Communication & Power, hardware, Software etc.



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Hybrid Approach - Captivate Monitoring App

Campaign Monitoring with Automation

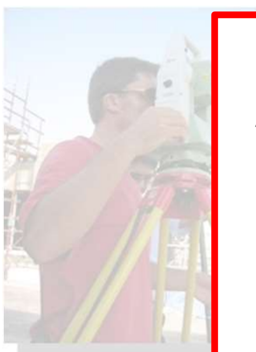
Manual Campaign Monitoring

TPS, GNSS, Level etc.
+
Office workflows

TPS
Monitoring
App

Geodetic Monitoring System
(permanent, continuous 24/7 monitoring)

Detailed long term installation with Communication & Power, hardware, Software etc.



Automated Campaign monitoring
Repeated deformation measurements

One or more TPS with Monitoring App
+
GeoMoS Now! Survey Edition

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Captivate Monitoring App

Field to Office Automation Workflow

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QUESTIONS?

Monitoring Solutions

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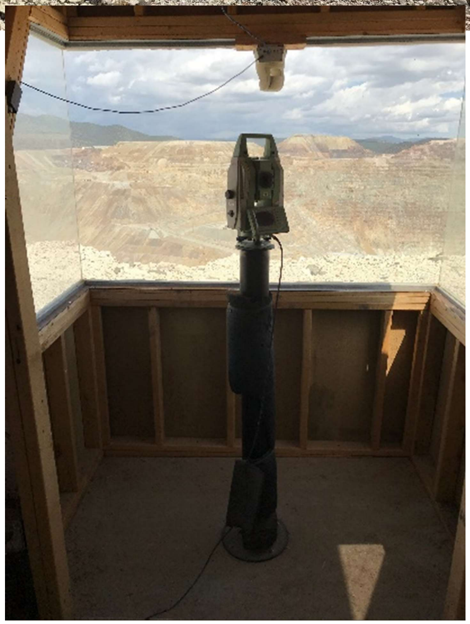
Project Example- Open Pit Mine

Slope Stability Monitoring



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Project Example- Open Pit Mine

Slope Stability Monitoring

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Project Example- Mine Tailings Dam

Berm/Earthen Dam Monitoring

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Project Example- Mine Tailings Dam

Berm/Earthen Dam Monitoring

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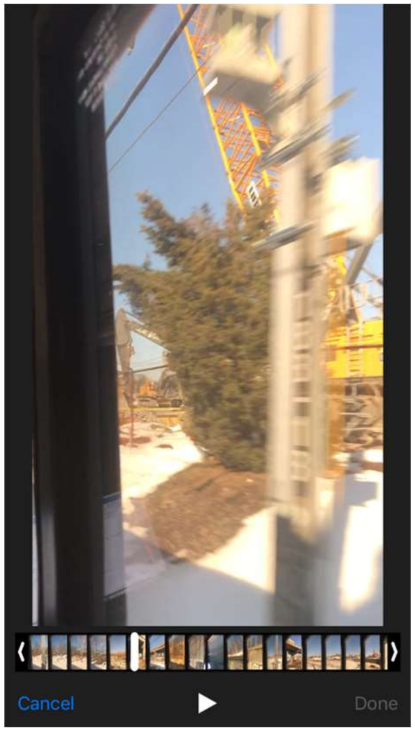
Project Example- Mine Tailings Dam

Berm/Earthen Dam Monitoring

Project Example- Rail Monitoring



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Project Example- Rail Monitoring

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Project Example- Landslide Monitoring

Project Example- Landslide Monitoring

Project Example- Landslide Monitoring

QUESTIONS?

Monitoring Solutions

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Thank you

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Leica Geosystems: Who we are and what we do-

- Worldwide leader in high precision engineering products and services that are used to capture and measure natural and man-made structures, enabling our customers to model and analyze spatial information.
- Provide solutions for structural health monitoring and real-time asset management
- The focus is on our customers to acquire high precision, accurate data that enables increased productivity and greater safety.

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Terrestrial Positioning Systems

TM60

TM60
- 3000 meter ATR range
- 0.5” or 1” angle rating
- 0.6 mm +/- 1 mm PPM
- Overview Imaging
- Telescope Imaging (30x)
- 3.5 km range to GPR112
- 1 km Reflectorless EDM

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Terrestrial Positioning Systems

TS/MS60

TS60

- 0.5 and 1” angle ratings

MS60

- 1” Angle rating
- 1 mm +/- 1.5 mm PPM EDM
- 1500 meter ATR range
- 2000 meter Reflectorless EDM
- 250-30000 pts per second scanning

Global Navigation Satellite Systems

GMX902

GMX 902/902GG Series

- Streaming receiver with remote antenna
- Multiple constellations/frequencies
- Feed raw data to Spider
- 50 Hz positioning

GMX910

GMX910 SmartAntenna

- Data streaming antenna/receiver
- Multiple constellations/frequencies
- Feed Raw Data to Spider
- 50 Hz Positioning

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Global Navigation Satellite Systems

AR-10

AR-20

AR-25

GM Series

- Receiver with remote antenna
  - •Multiple constellations/frequencies
  - •Feed raw data to Spider/FTP/Crosscheck
  - •Spider to GeoMoS Monitor
  - •RTK Base/Rover data streaming direct to GeoMoS Monitor
  - •50 Hz positioning
  - •Multiple Antenna choices
  - •Internal or external radio/cellular
  - •Web interface for configuration/updates/remote operation
  - •VADASE (velocity/displacement engine)
  - •Long cable and amplifier capable

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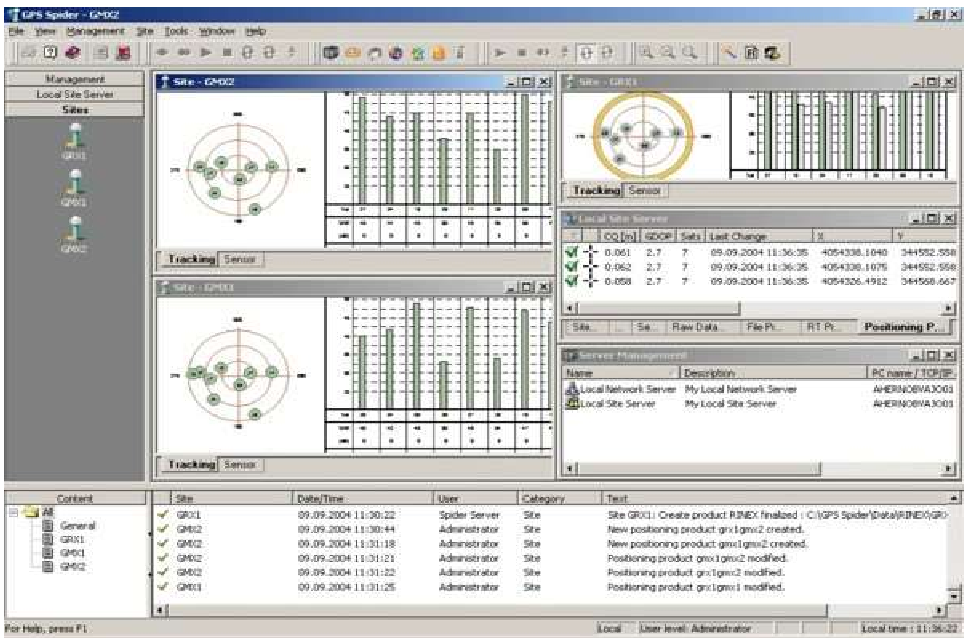
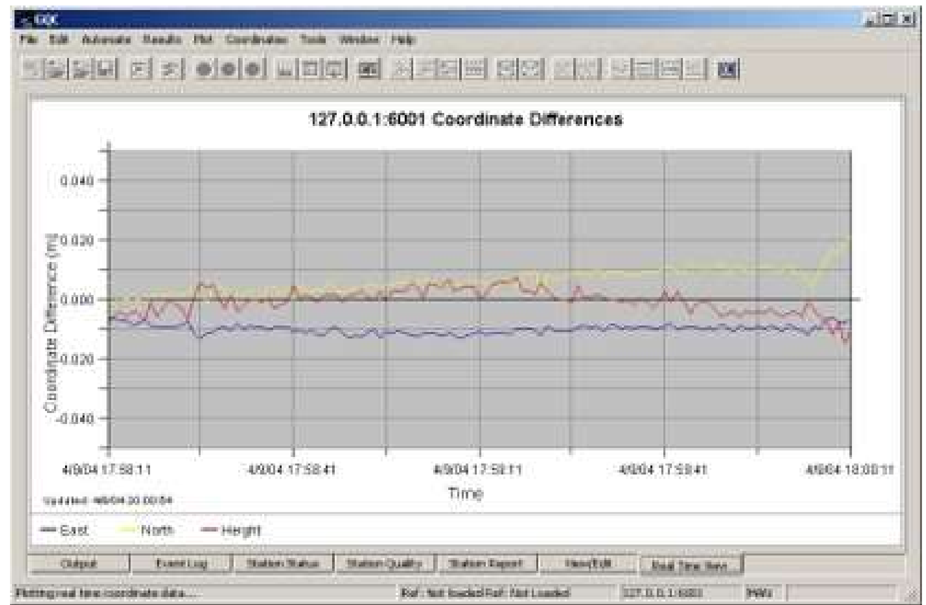
GeoMoS Spider

GPS software is capable of managing GPS receivers and processing centrally all combination of baselines at the highest rate (50Hz) with ultimate accuracy in both real time and post-processing.

- The results are available in, TCP-IP ports, files or SQL DB for sharing of the data to analysis software.
- The “re-processing” option allows the project operator to review step by step the results obtained.





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WisenmeshNet Wireless Monitoring Sensors

- The SmartGateway & mesh nodes wake up at a set interval
- The sensors take their readings
- All mesh nodes measure telemetry parameters
- All mesh nodes ping and listen for returns then form a dynamic optimised mesh automatically
- Node data is transmitted layer by layer
- SmartGateway transfers data
- System enters hibernation

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Typical devices

WiSenMeshNET: SmartGateway & power

SmartGateway

3303165 / 8251221

System controller and Data hub for MeshNET connectivity

Local memory

DC/AC power

Up to 1 year battery

Battery pack

0109015 / 8251250

Additional DC power

Up to 2 year battery

Solar

3303147 / 8251247

Renewable DC power

Vision unit

3303139 / 8251241

HD IR Camera

Visual warning system

Mini SmartGateway

3303096 / 8251225

Local mesh interface

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Typical devices

WiSenMeshNET: Sensors

Tilt

3303079 / 8251228

Dual Axis Tilt
Range 30° / ±0.0025°

Up to 10 year battery

Mini Tilt

3303097 / 8251229

Dual Axis Tilt
Range 30° / ±0.0025°

Up to 3 year battery

Visual Warning

3303140 / 8251242

3 colour LED

Edge computation for alarm trigger activation

Omni Tilt

3303168 / 8251514

Omni Axis Tilt
360° / 0.001°

Gravitational orientation

Up to 10 year battery

Omni Tilt & Distance

3303109 / 8251231 (33m)

3303110 / 8251232 (100m)

Omni Axis Tilt
360° / 0.001°

Laser Distance sensor
±0.1mm / 0.3>100m

Up to 10 year battery

Tilt & Compass

3303068 / 8251230

Omni Axis Tilt
Range 360° / ±0.001°

Gravitational orientation

Magnetic compass

Up to 10 year battery

Typical devices

WiSenMeshNET: Interface systems

Vibrating Wire

3303112 / 8251237 (1CH)

3303077 / 8251238 (4CH)

3303113 / 8251239 (8CH)

Up to 8 connections

400 to 6000Hz @ ±0.015%

±0.002Hz@400Hz

±0.050Hz@6000Hz

Analog

3303087 / 8251240

Up to 2 connections

4~20mA

1~5VDC

± 0.1% / ±0.0003mA

±0.0001V

Digital

3303111 / 8251233 (1CH)

3303105 / 8251234 (4CH)

Up to 4 connections

Custom RS485 interface

Foil Gauge

TBC

Up to 6 connections

Range 119.0 ~ 121.0 Ω

0.1% ± 0.0005 Ω

Captivate Software- Monitoring Application

- Onboard instrument or data collector
- Automates campaign style monitoring with automated data push to Now! for reporting

TPS single measurement

TPS or Level or …
+
Infinity
Local software
MS Excel

Geodetic Monitoring System
(permanent, continuous 24/7 monitoring)

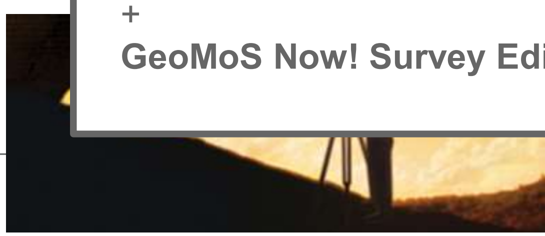
Detailed long term installation
With Communication
& Power
utilizing
GeoMoS Monitor
GeoMoS Now!

Captivate Software- Monitoring Application

- We now offer a solution for simple monitoring setup:

TPS single measurement

TPS or Level or …
+
Infinity
Loca
MS E



Geodetic Monitoring System
(permanent, continuous 24/7 monitoring)

Detailed long term installation
With Communication

Monitor
Now!

Campaign monitoring
Repeated deformation measurements

One or more TPS/level
+
GeoMoS Now! Survey Edition

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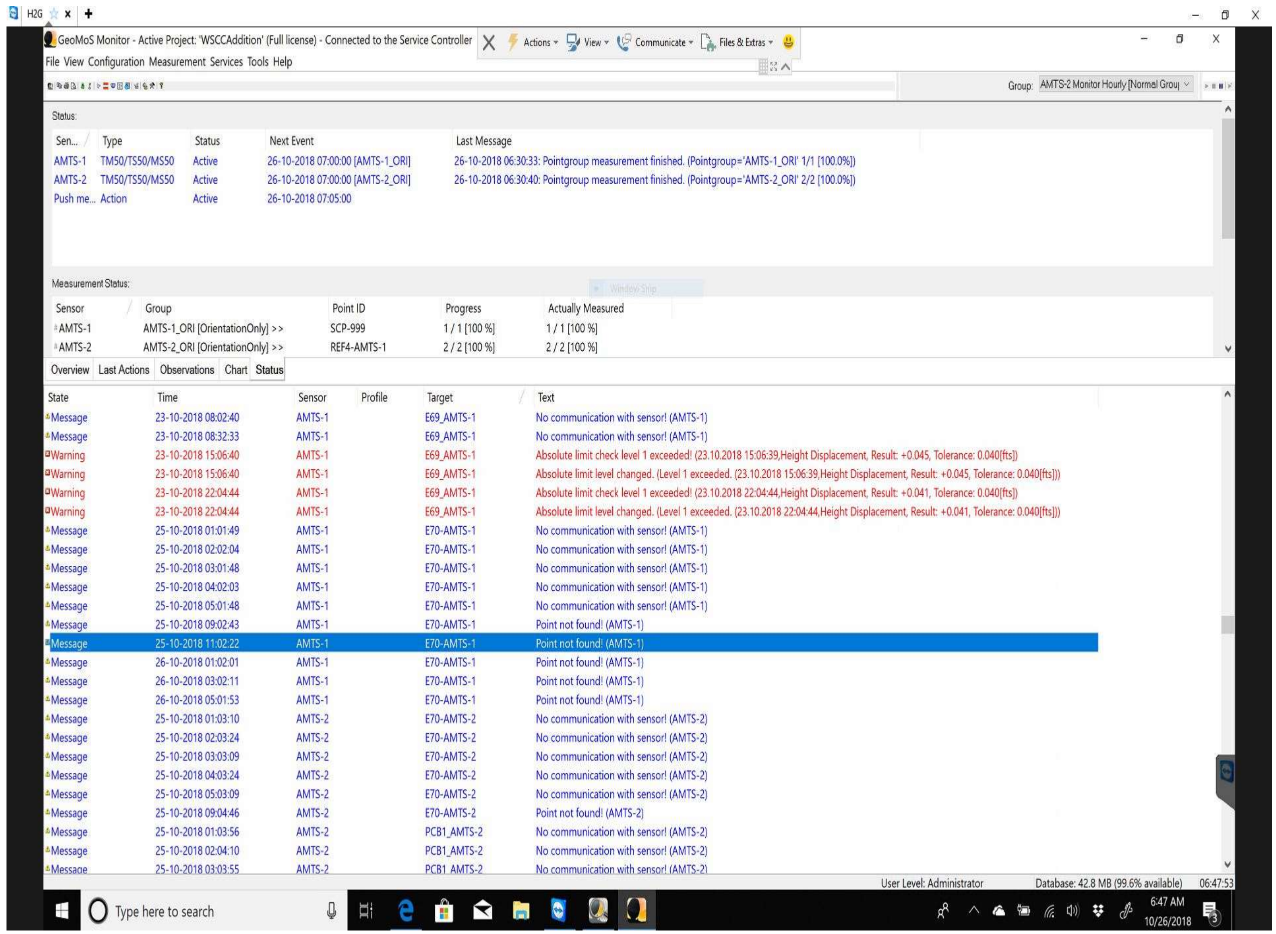
GeoMoS Software

- GeoMoS Monitor
  - Data collection and control platform
  - Limit Checks and Messaging option
  - Computations option
  - Export to Adjustment option
  - API option
  - Scanning Option
- GeoMoS Analyzer
  - Detailed, multi prism analysis, plotting
  - Recalculation of data, prism changes, atmospherics
- GeoMoS Adjustment
  - Epoch based least squares network adjustment
  - Epoch based deformation analysis and adjustment



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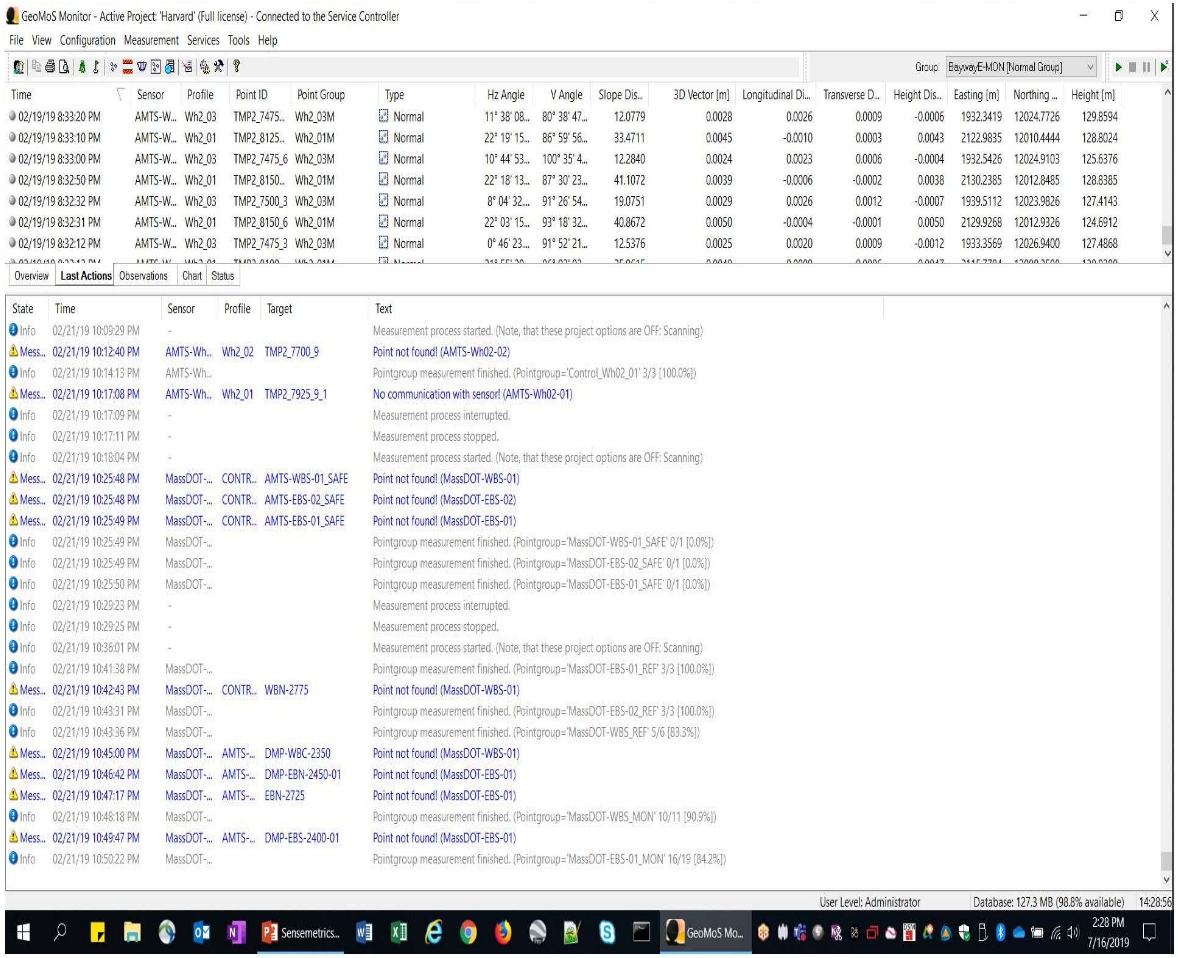
Surveying Concepts

Fundamentals

- GeoMoS is the interface for all measurements
  - Instrument management
  - Point management
  - Calculation platform that turns measurements into positions from which displacements are calculated
  - Remote positioning
  - Simple analysis
  - Exporting tool
    - API
    - Adjustment
    - Now!



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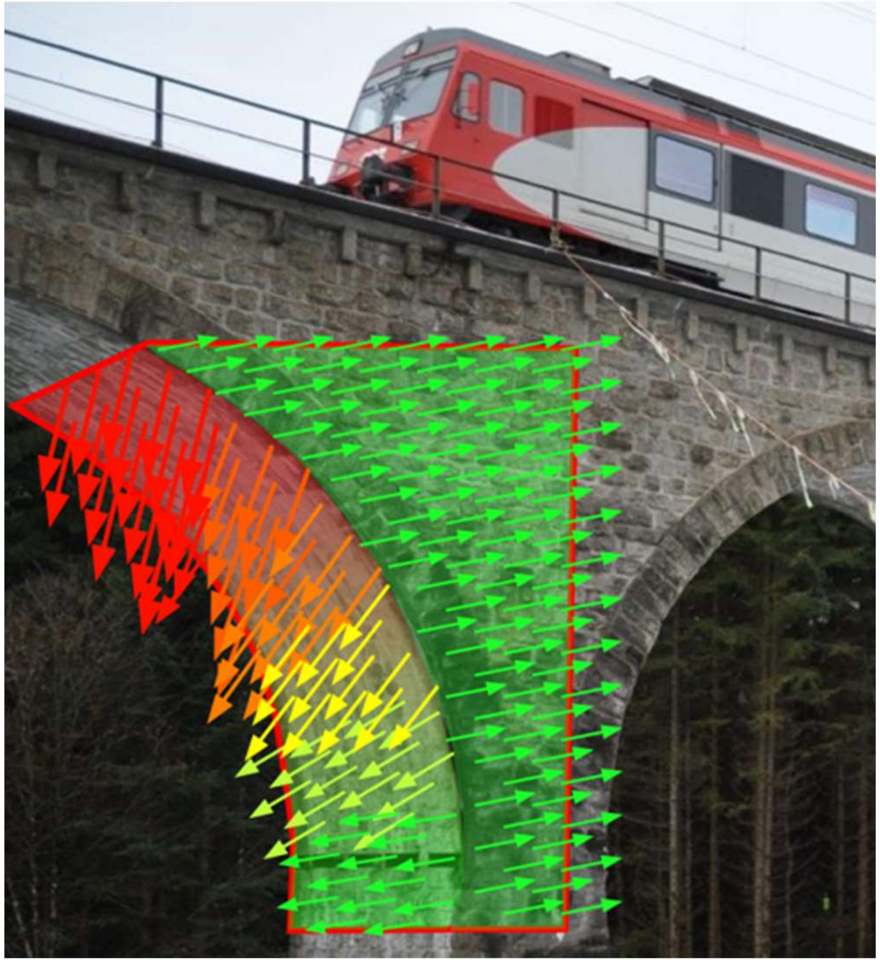
MS-60 and GeoMoS Scanning



- Scanning based Monitoring
- Unattended area monitoring via standard measurement cycle
- Reporting, change calculations
- Image based work areas
- Displacement engine will identify vector of change

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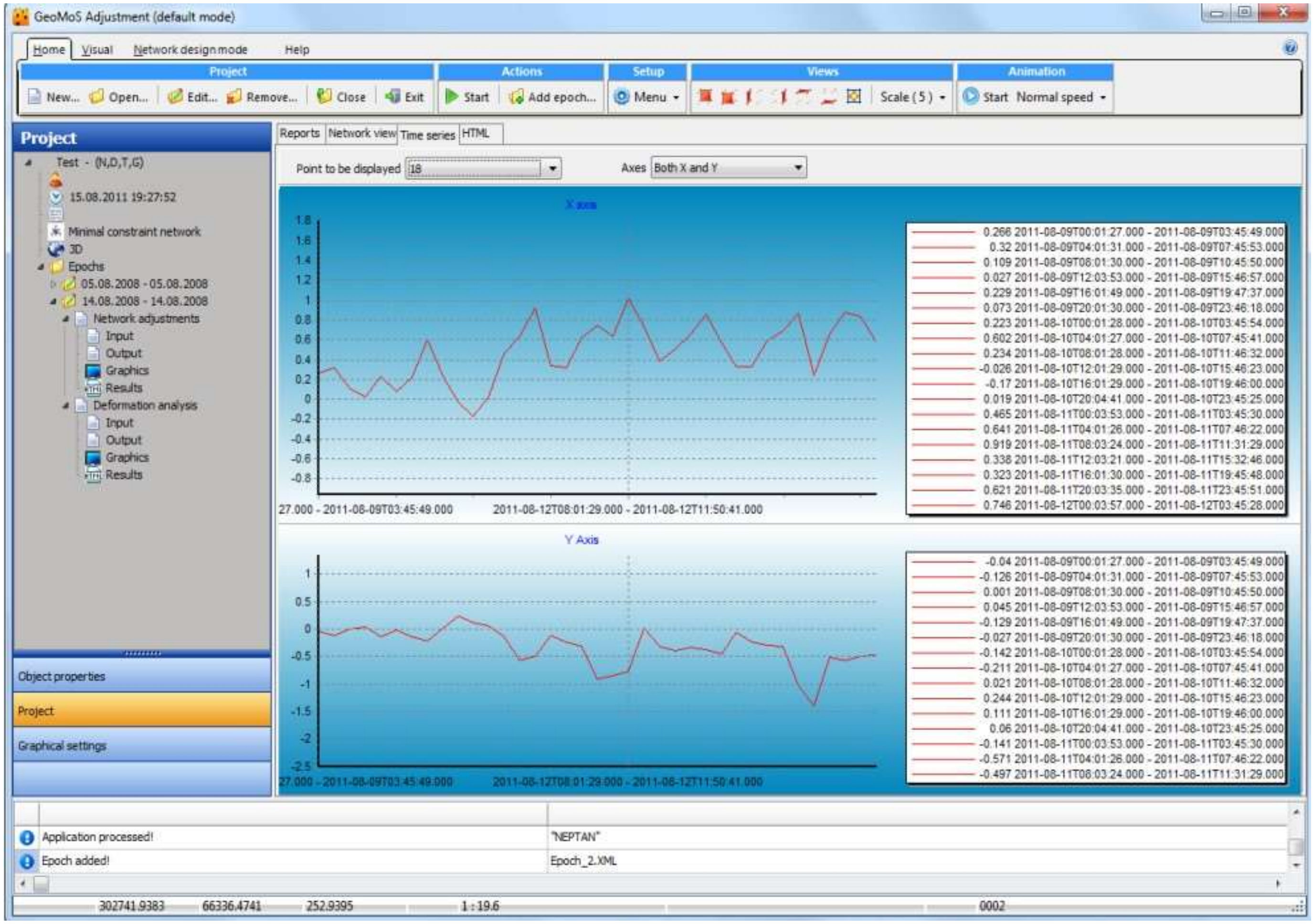
GeoMoS Adjustment

Least Squares Automated Adjustment Workflow

- High Precision/Accuracy
- Neptan based engine
- Increased data confidence
- Integrates GNSS/Instrument/Met sensor data
- Based on redundancy of data
- Feeds results back to GeoMoS



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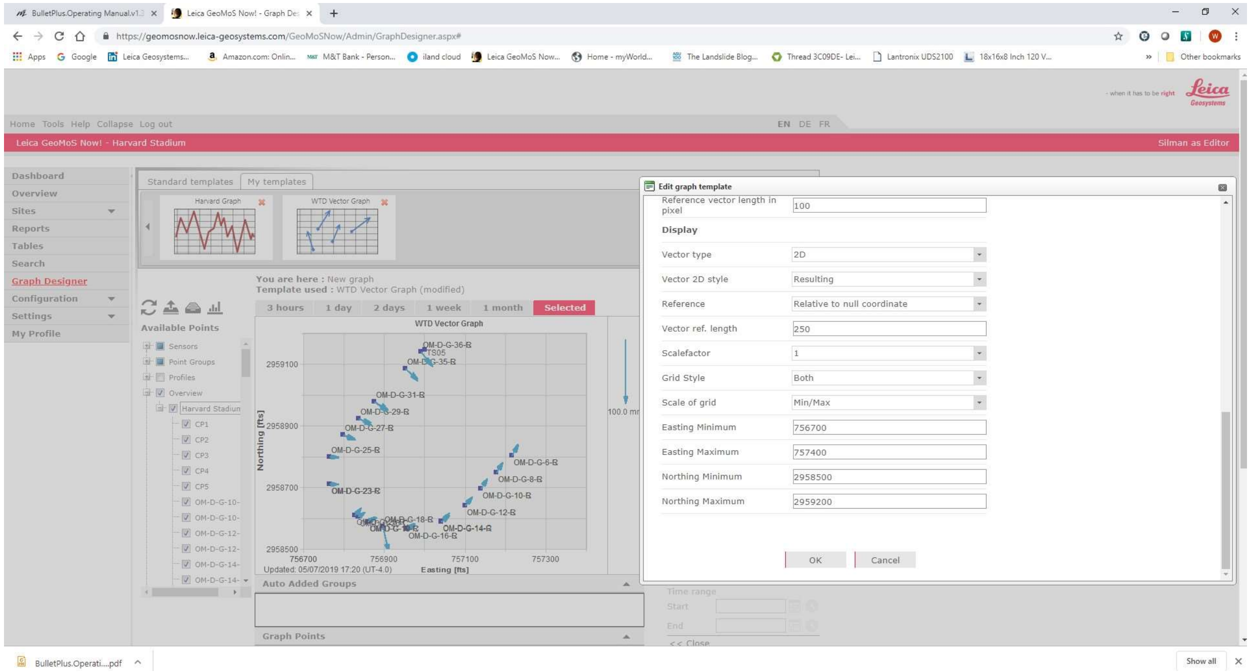
GeoMoS Now! and Now! Survey Edition

GeoMoS Now!

- Quarterly and Annual Subscription based web Application
- Enterprise Version

GeoMoS Now! Survey Edition

- More Surveying features available to support Monitoring Application
    - Import points



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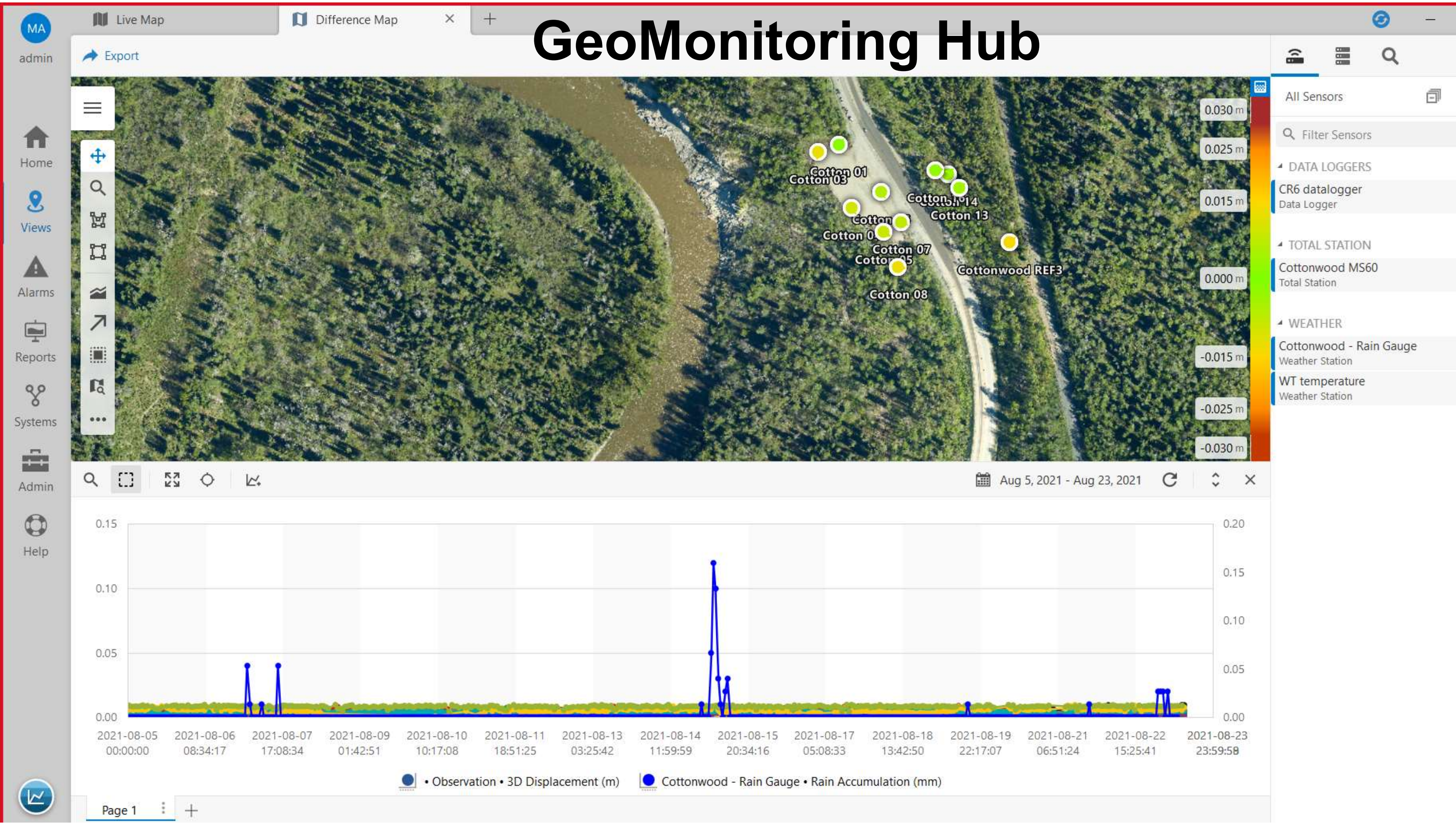
GeoMonitoring Hub



QUESTIONS?

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Thank you

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