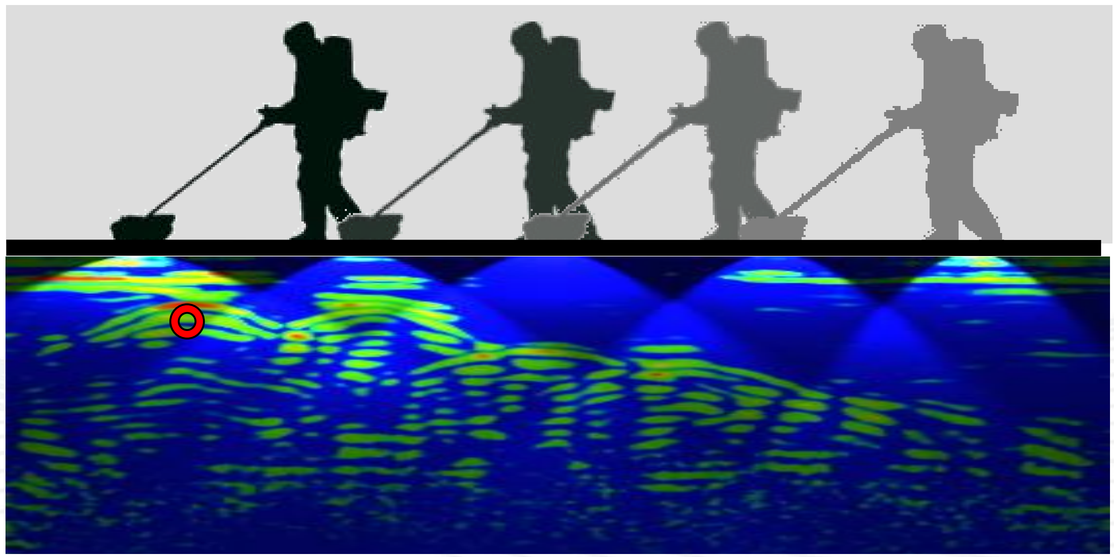
GEORADAR



GPR: Theory and technology

Index

- Module 1: GPR theory and applications
- Module 2: Factors affecting GPR performance
- Module 3: GPR for utility locating
- Module 4: GPR for utility mapping
- Module 5: Live demo of a dual-frequency GPR and a multichannel (32 channels) dual-polarized GPR

Module 1: GPR theory and applications

This module will cover the following topics:

- Fundamentals
- Principle of GPR functionality
- Parameters of influence and performance
- Radar map interpretation, applications and examples

❑ Que es un GEO-RADAR?

Un RADAR aplicado a sondeos del subsuelo u otro medio material.

Distintas Acepciones:

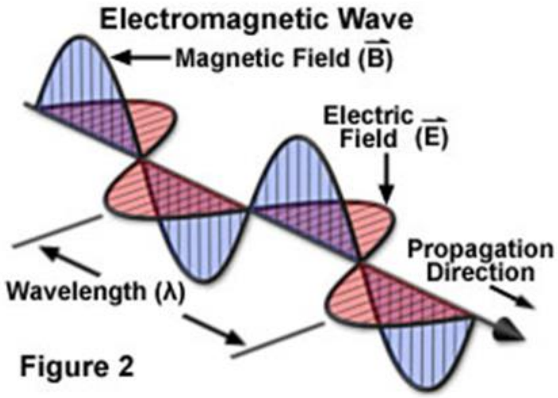
Radar de Superficie		Surface Pene... Radar		SPR
Radar de Penetración en t... rra	<>	Ground Penet... ting ...adar	<>	WPR
Georadar / Radar de su...suel...		**Ground Probin... Rad...r.**		**GPR**

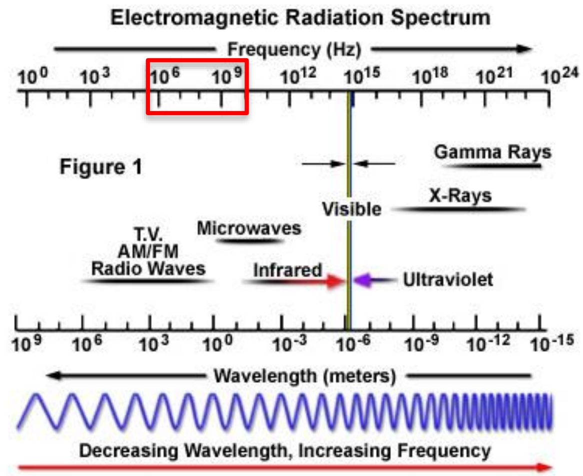
Histor...

- Las p... equipo GPR datan de p...
- A pa... ” (1942) creciente inte...
- ... uerte evolución.
- A ... mas ampliamente conocido y recono...
  - Aumento en investigación y publicaciones.
  - Primeras empresas en España.
- En países como EEUU, Canadá ó Finlandia ya es utilizado de forma rutinaria en distintos ámbitos de la ingeniería civil.

Electromagnetic waves

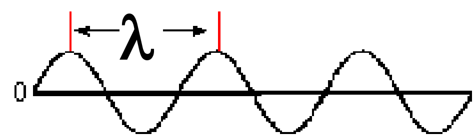
- **GPR uses high frequency pulsed electromagnetic waves (from 25MHz to 2,000MHz) to acquire subsurface information.**





- **The formula for wavelenght for light is given by** λ=c/f

$$\lambda_{meter} = \frac{3x10^8}{f_{Hz}} \quad or \quad f_{Hz} = \frac{3x10^8}{\lambda_{meter}}$$

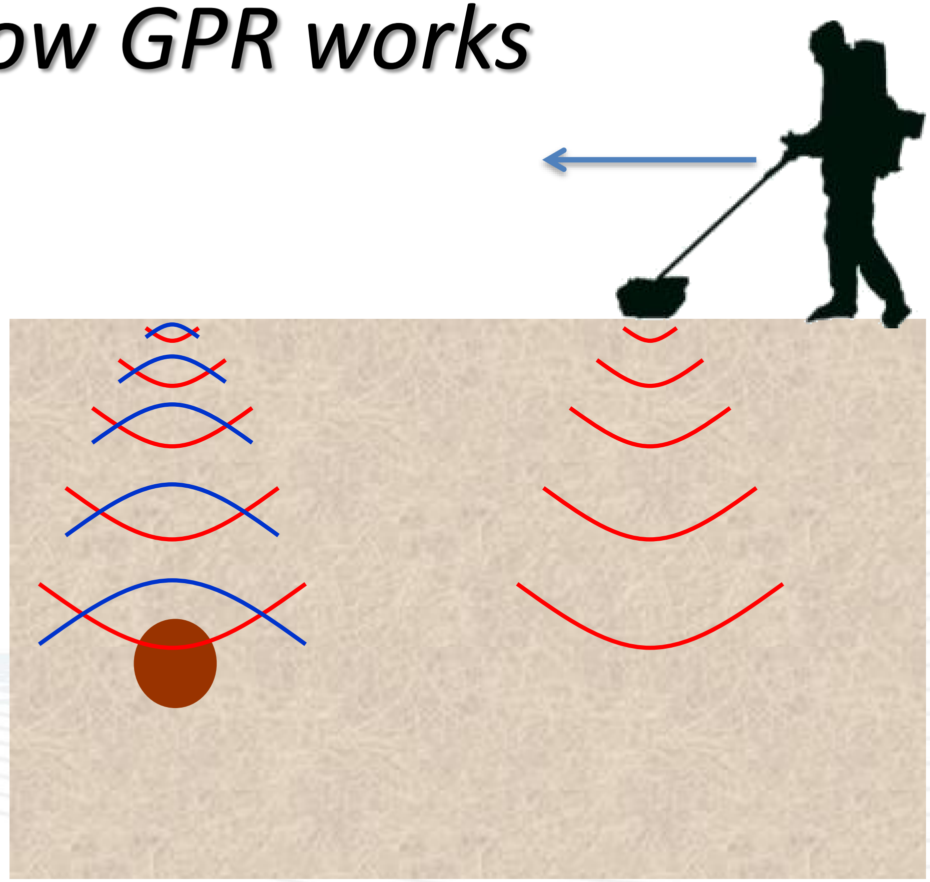


GPR theory and technology

- Module 1: GPR theory and technology
  - Fundamentals
  - GPR principles
  - Parameters of influence and performance
  - Radar map interpretation

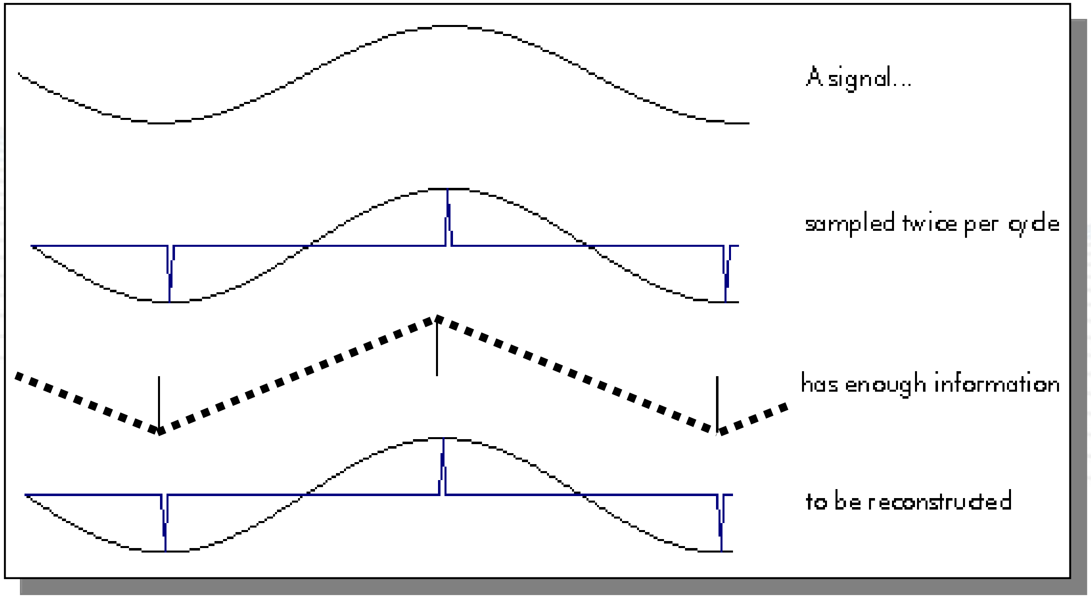
Basics of how GPR works

- The GPR system sends a short pulse of EM energy by the antenna transmitter.
- The reflected energy from each discontinuity is captured by the antenna receiver.
- Targets' depth can be estimated using the information contained on the reflected energy (time delay and amplitude).
- The depth of penetration and resolution are related to the antenna's frequency, the emission power and the dielectric properties of the materials.



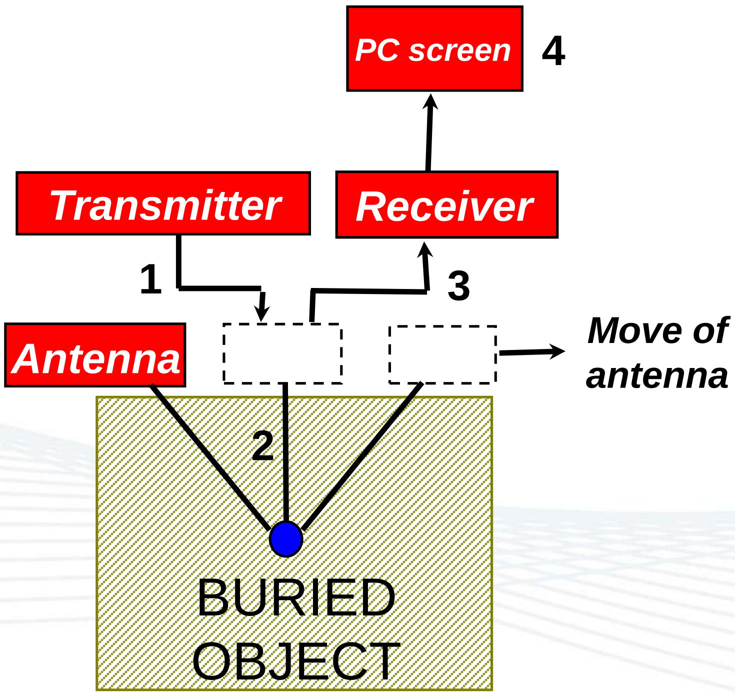
Sampling theory

- Each received signal is sampled and saved in digital format by a DIGITAL ANTENNA DRIVER (DAD).
- Nyquist sampling theorem states that in order to adequately reproduce a signal it should be periodically sampled at a rate that is twice the highest frequency you wish to record.

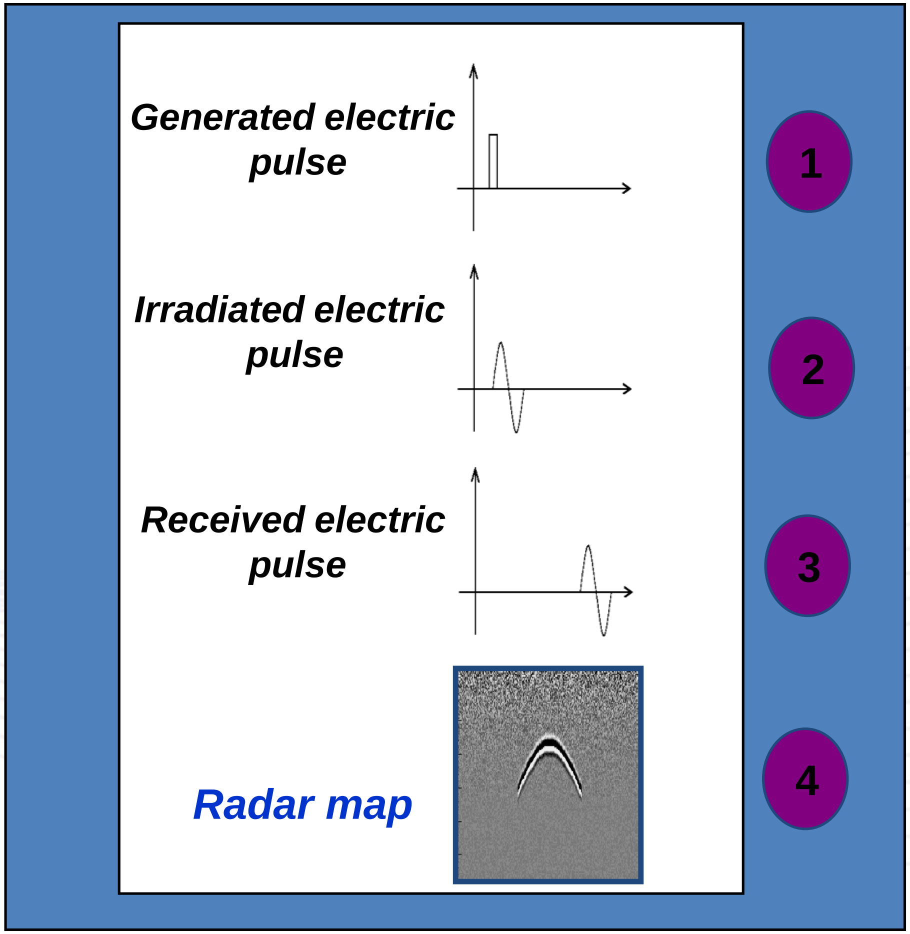


$$f_s > 2 f_{max}$$

Generation of the map

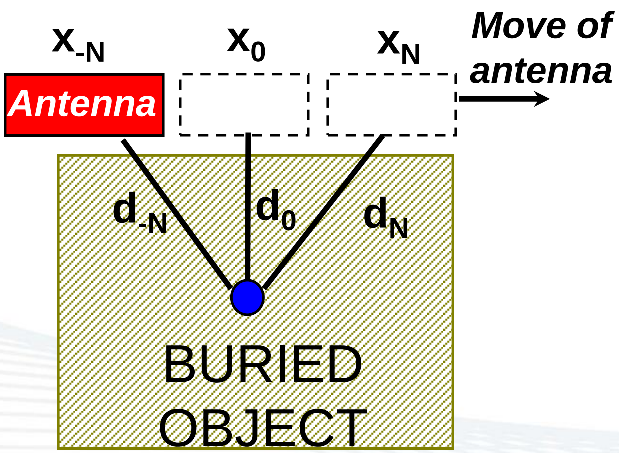


Sketch of principles

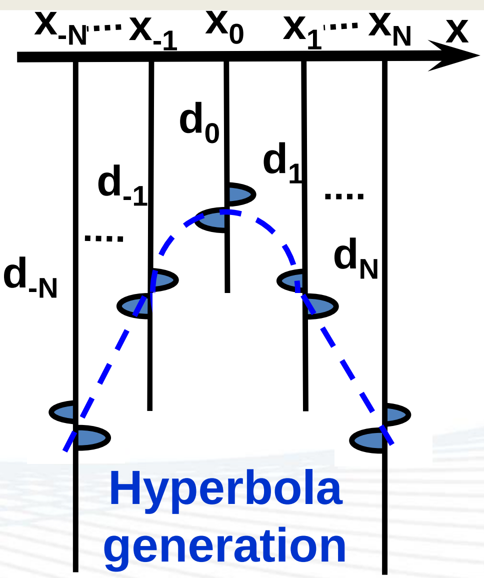


Generation of the map

Buried object is seen by GPR in deformed shape



Data acquisition

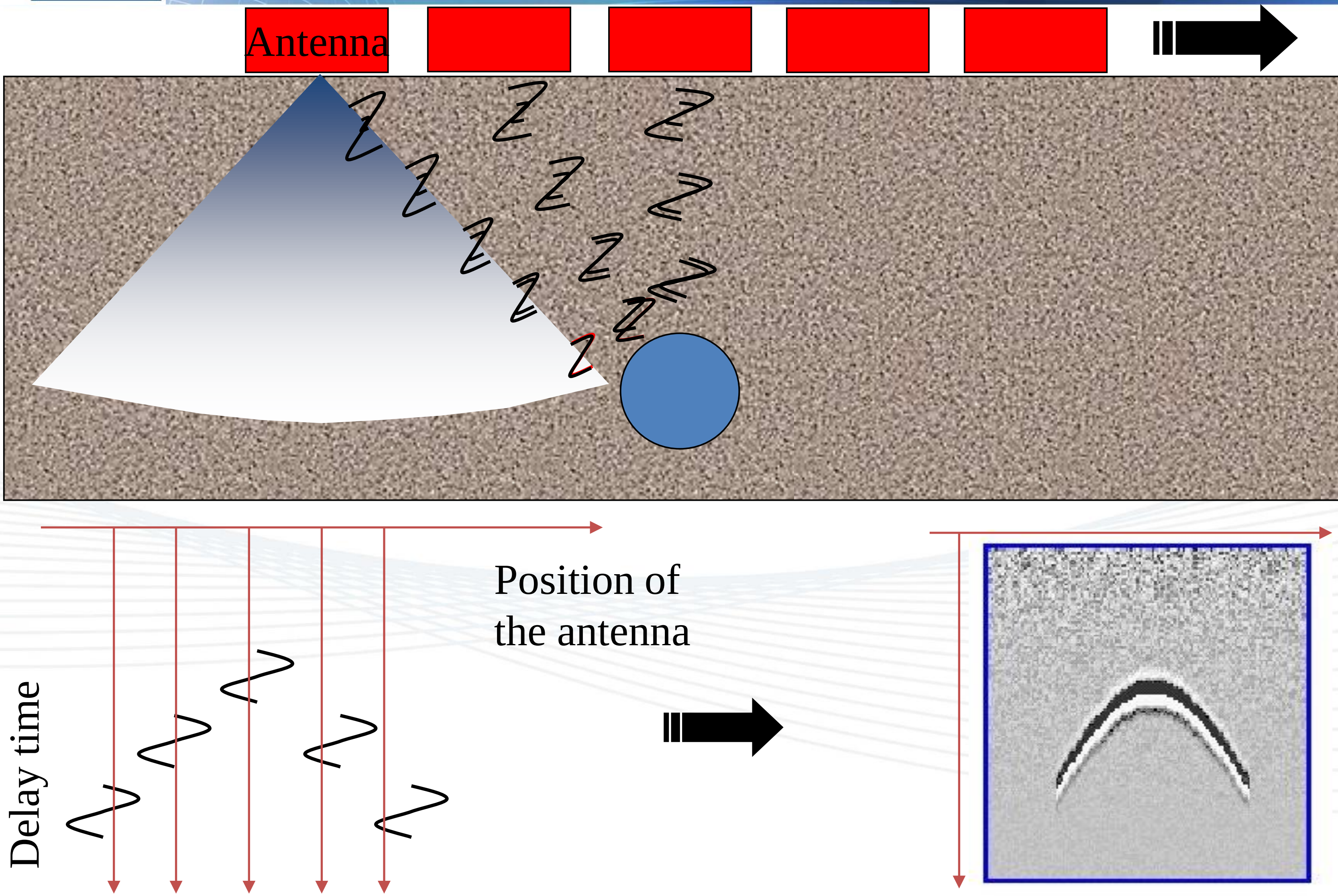


Hyperbola generation

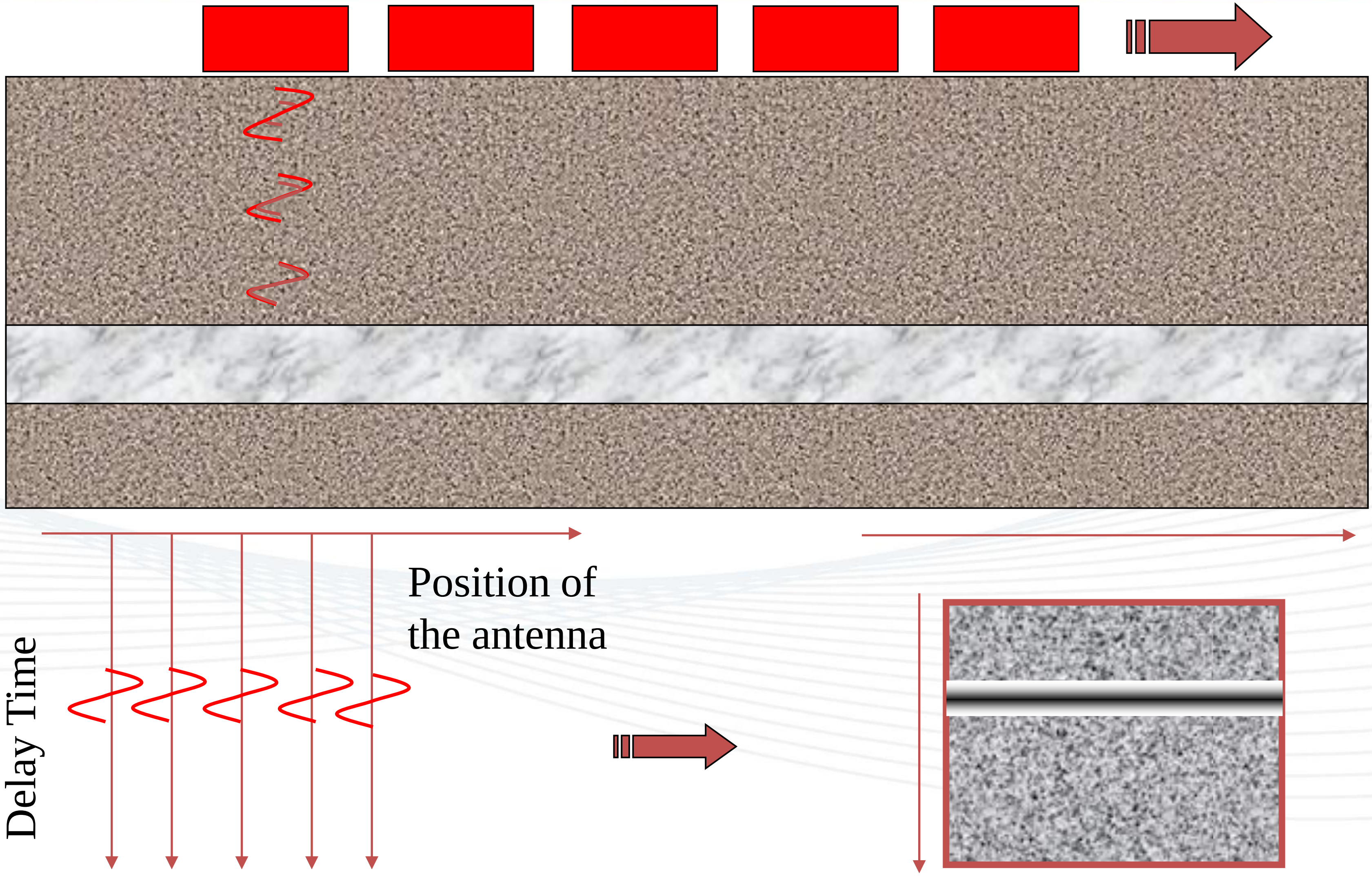
Radar map

A buried object is detected if:
- It is within the antenna footprint
- There is sufficient signal-to-noise ratio

GPR principles - Map generation



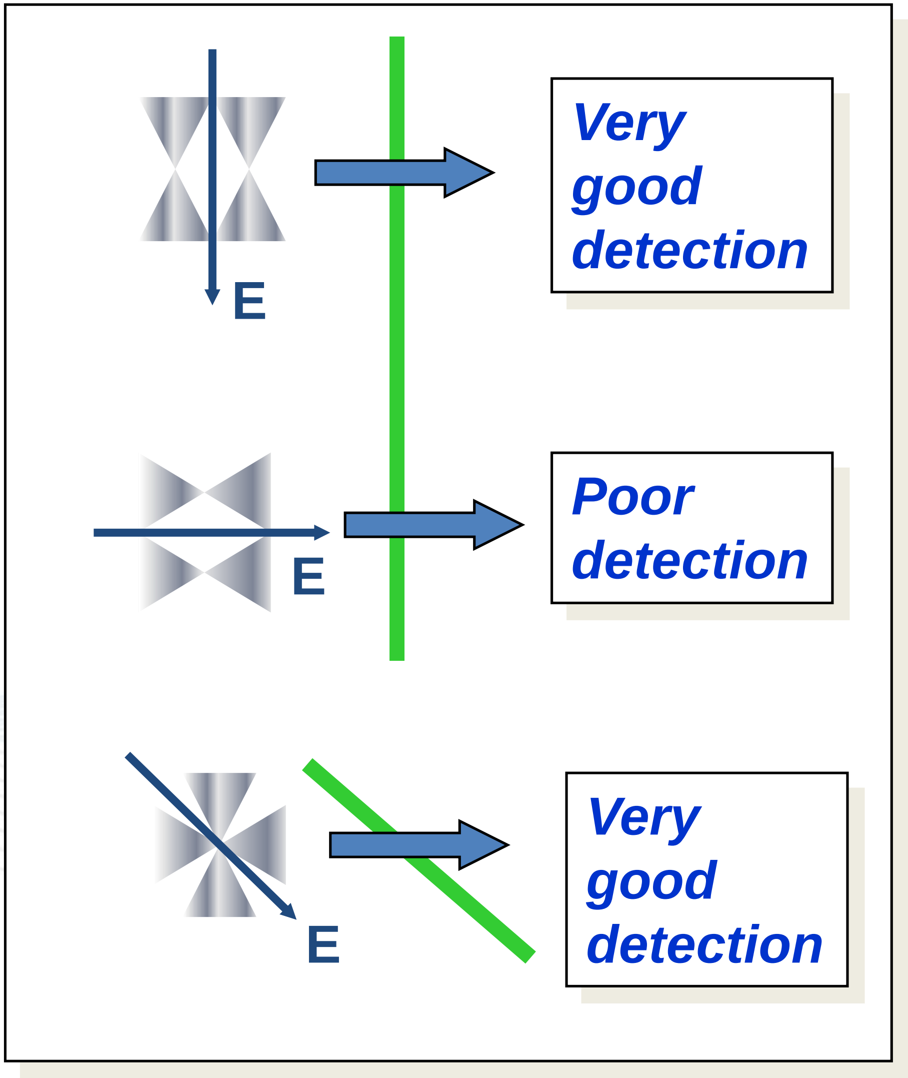
GPR principles - Map generation



Characteristics of the antennas

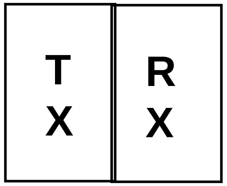
Polarization:

- One important characteristic of antennas is their polarization. That is the direction of irradiated and received fields.
- The targets are detected more clearly if the vector Electric Field (E) is parallel to them during the scan.
- With the co-polar antennas, we can detect the perpendicular targets respect to the scan direction.
- With the cross-polar antennas we can detect better the targets being at 45° respect to the scan direction.



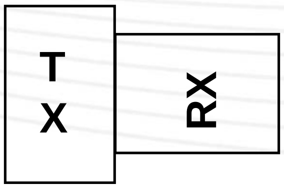
Characteristics of the antennas

- Monostatic type: TX-RX attached between them and located in the same case.

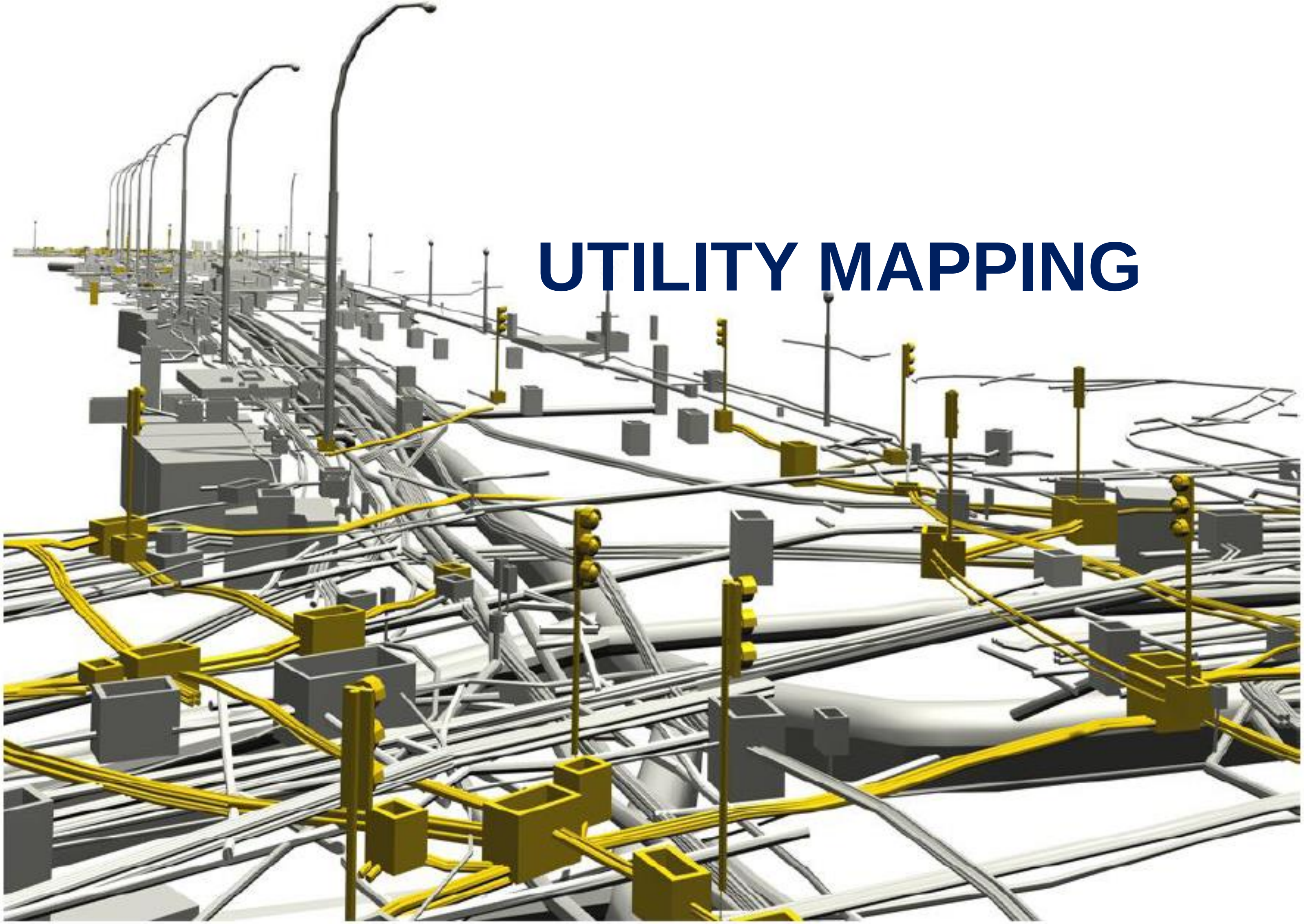


- Bistatic type: TX-RX spaced and located in different cases.

- Crosspolar type: TX-RX perpendicular between them.



APPLICATIONS



UTILITY MAPPING

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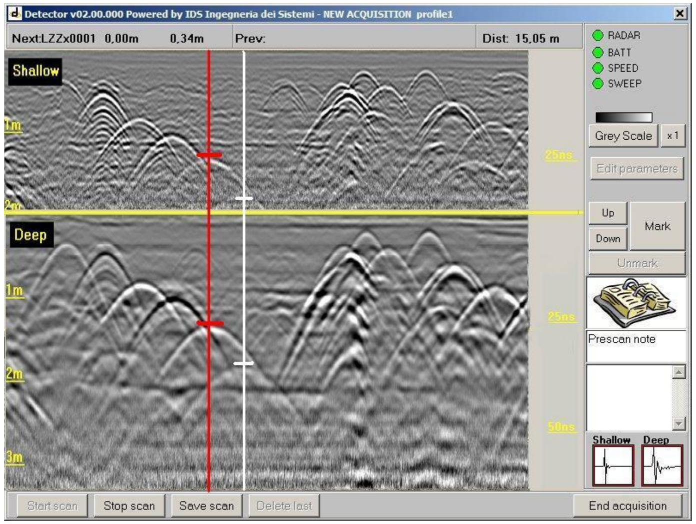
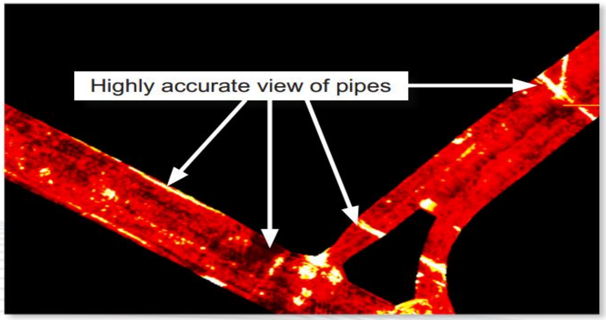
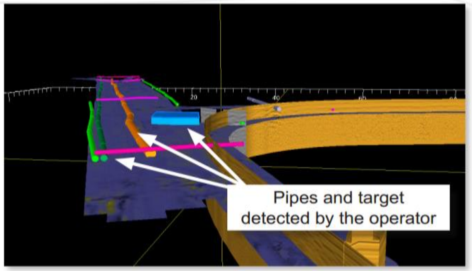
UTILITY DETECTION AND MAPPING





GRED HD 3D CAD: subsurface time slice view



GRED HD 3D CAD: 3D post processing results

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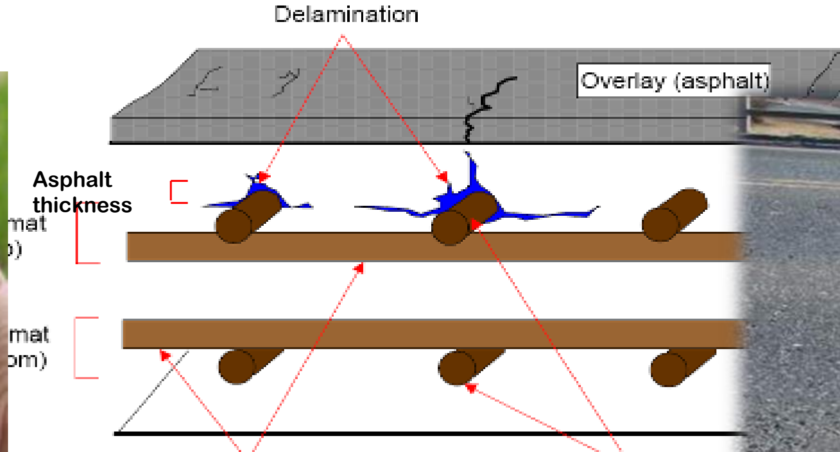
PUENTES



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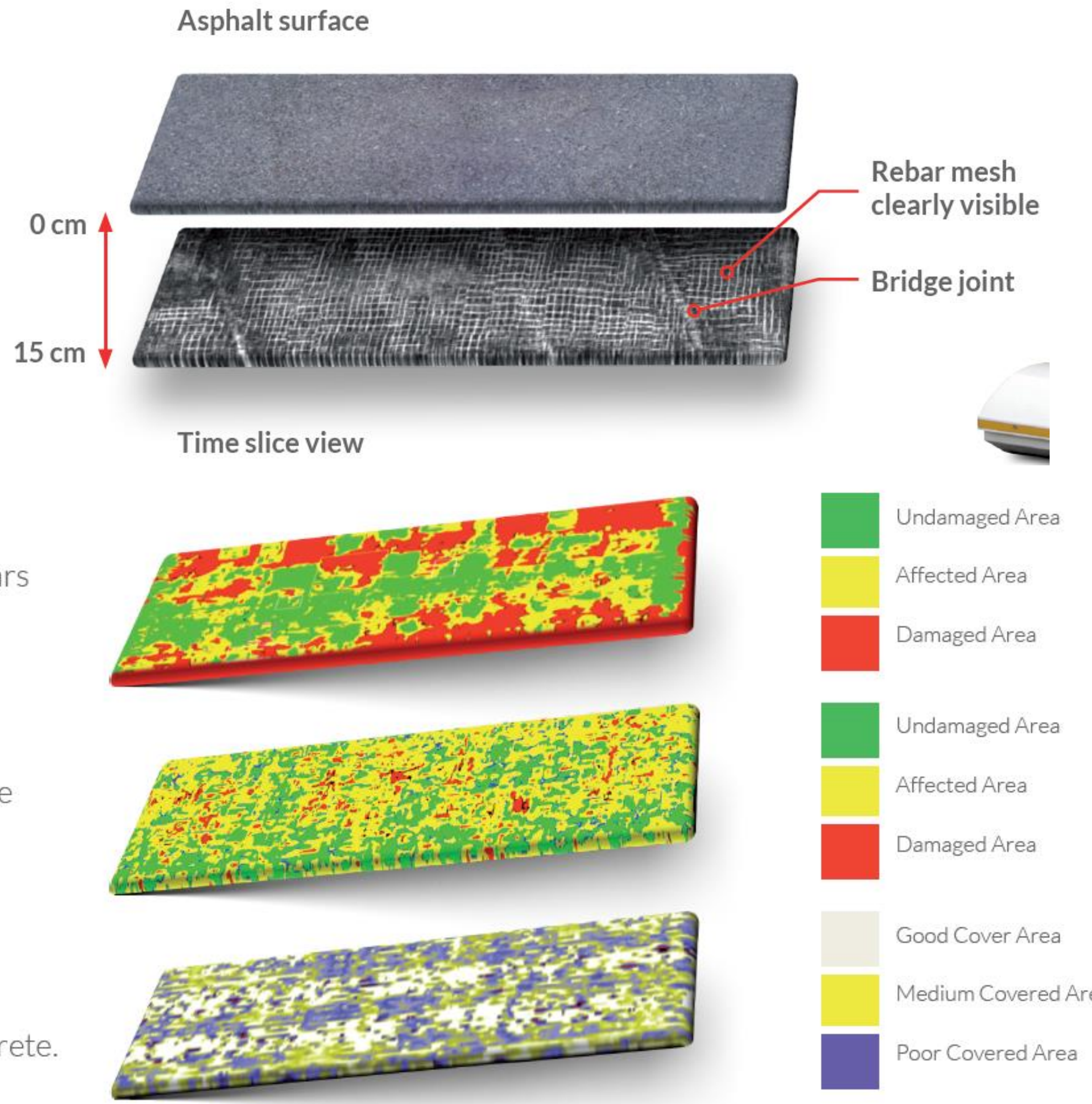
RIS Hi-BrigHT

The only dedicated radar solution for bridge deck surveying

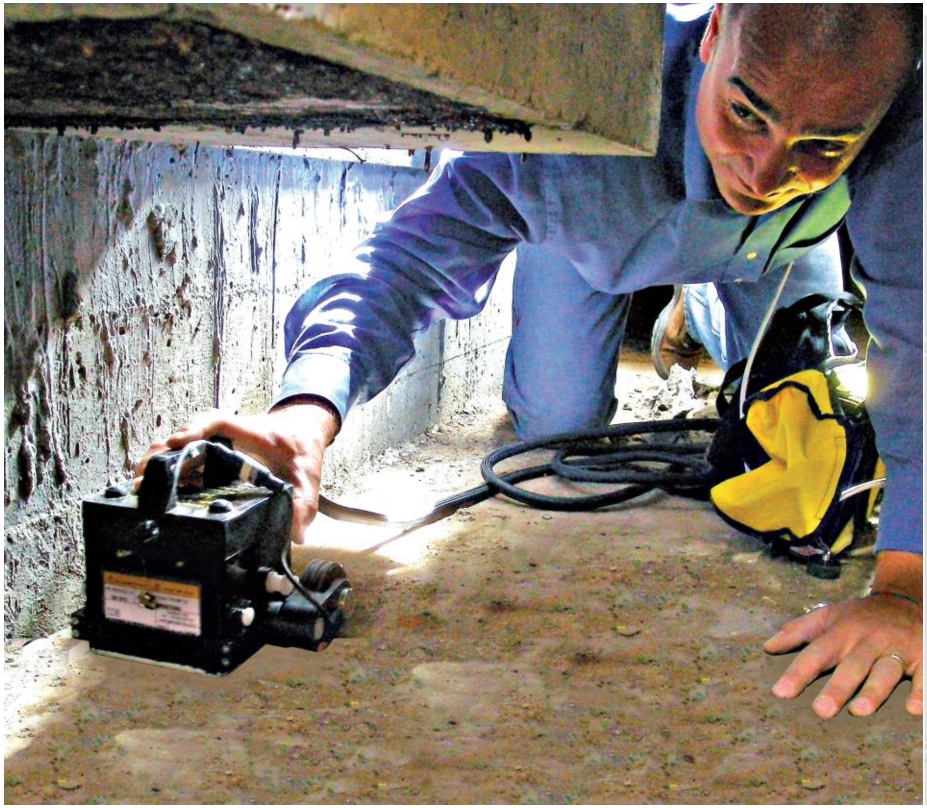


Corosion Map
is the amplitude of the detected rebars and it is expressed in Volts

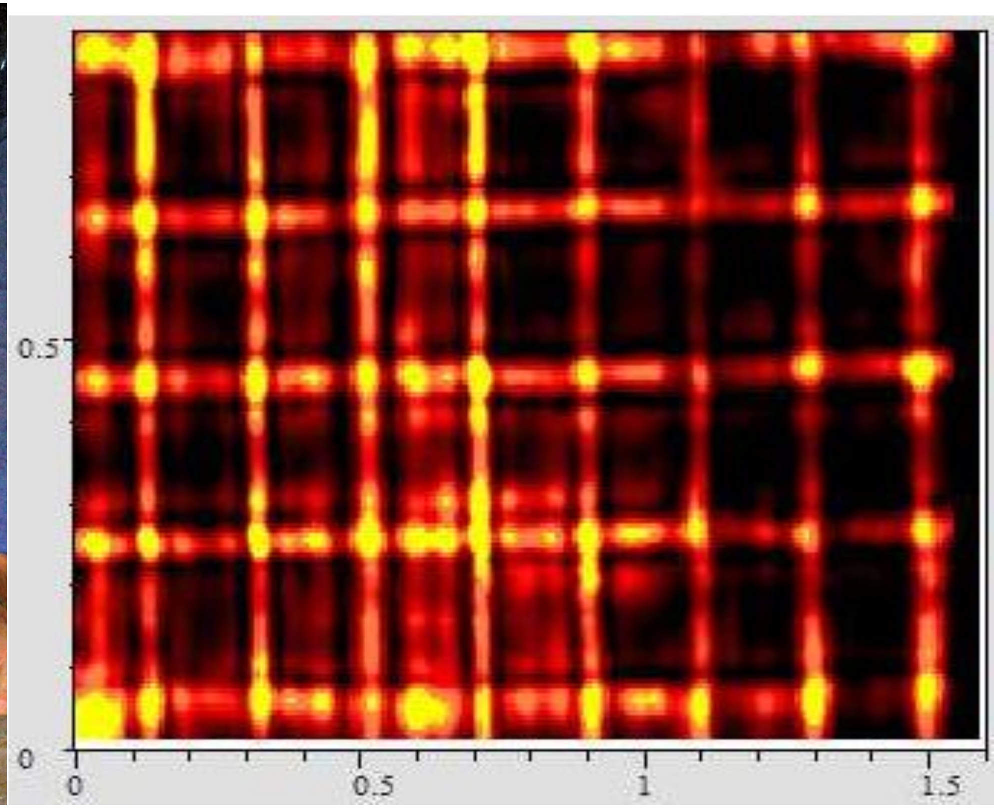
Moisture Map
represents an estimate of the propagation velocity calculated at the rebars interface.

Concrete cover thickness map
identifies the boundary between the asphalt and concrete layers and represents the thickness of the concrete.

CONCRETO (barras de acero)

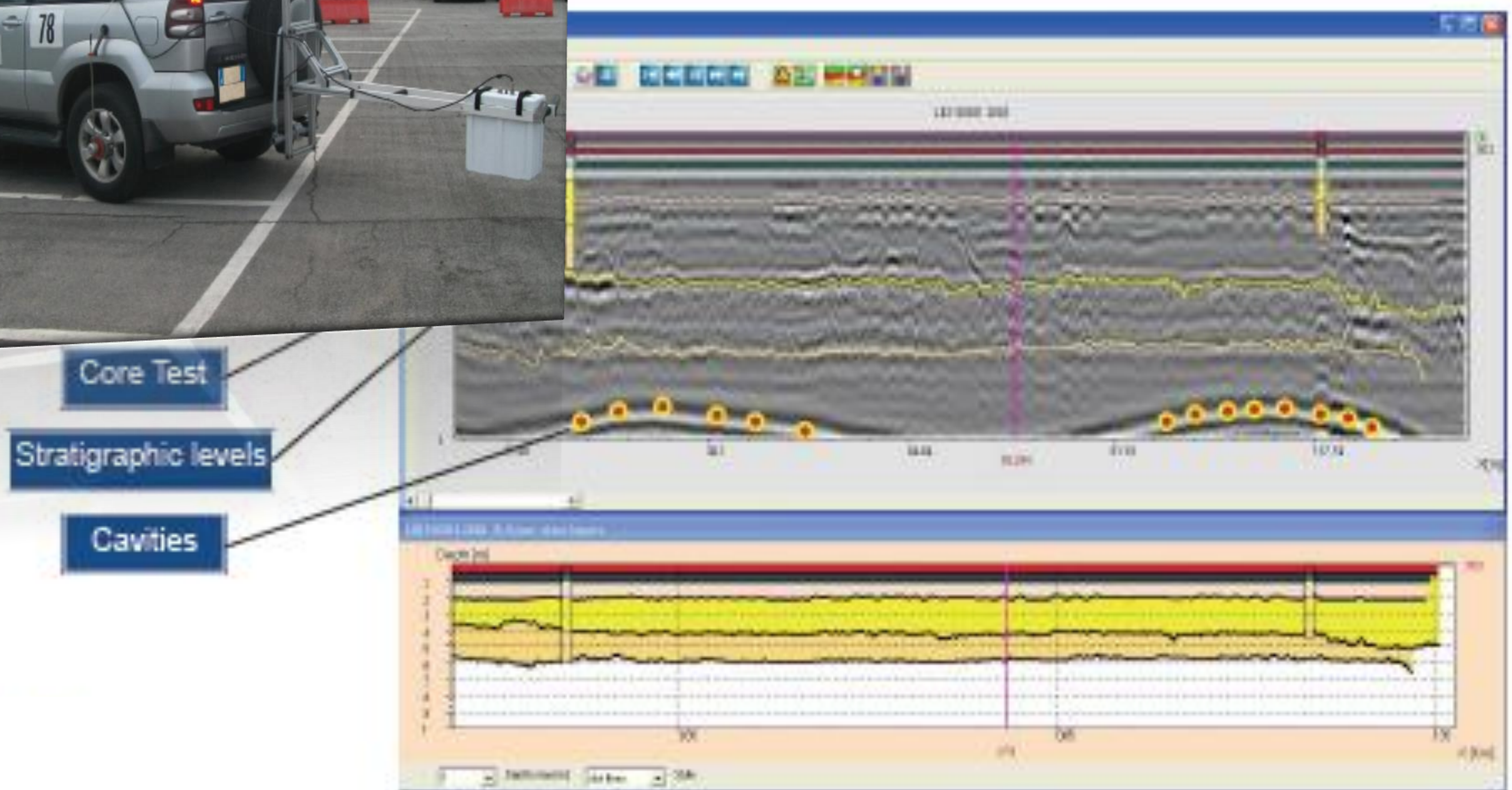


Depth: 0.10m

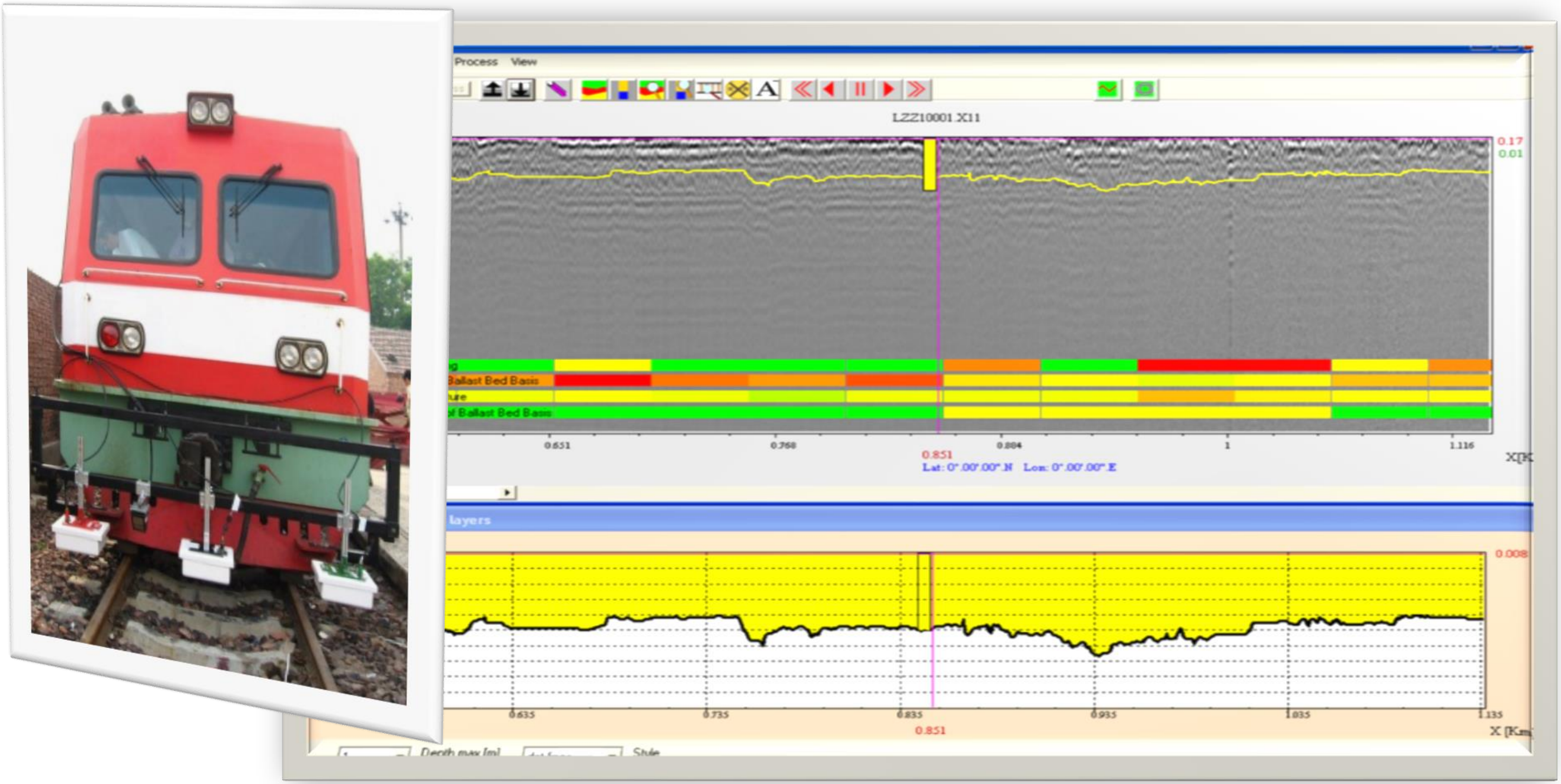


PAVIMENTOS

RIS Hi-Pave



LINEAS FERROVIARIAS



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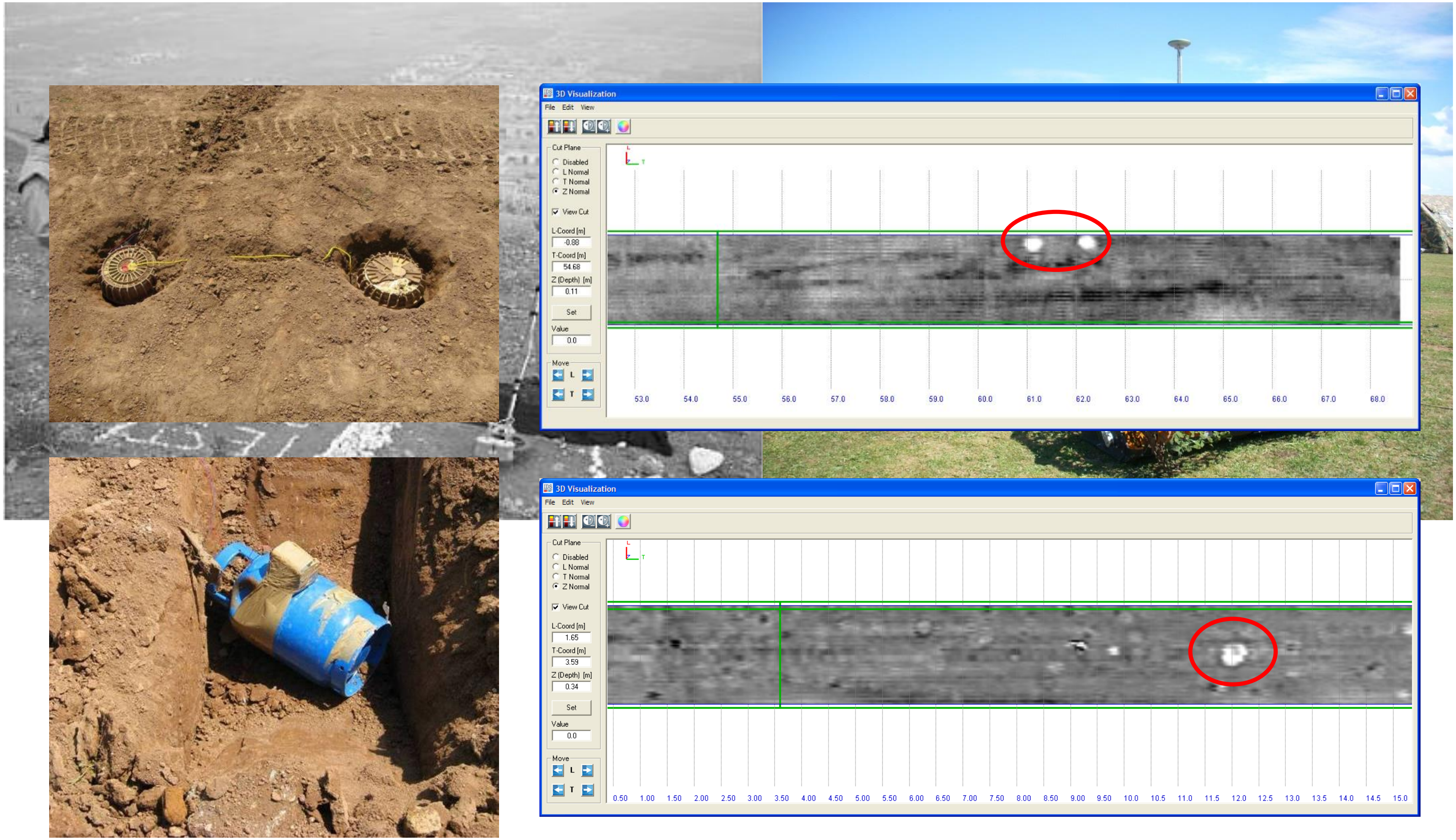
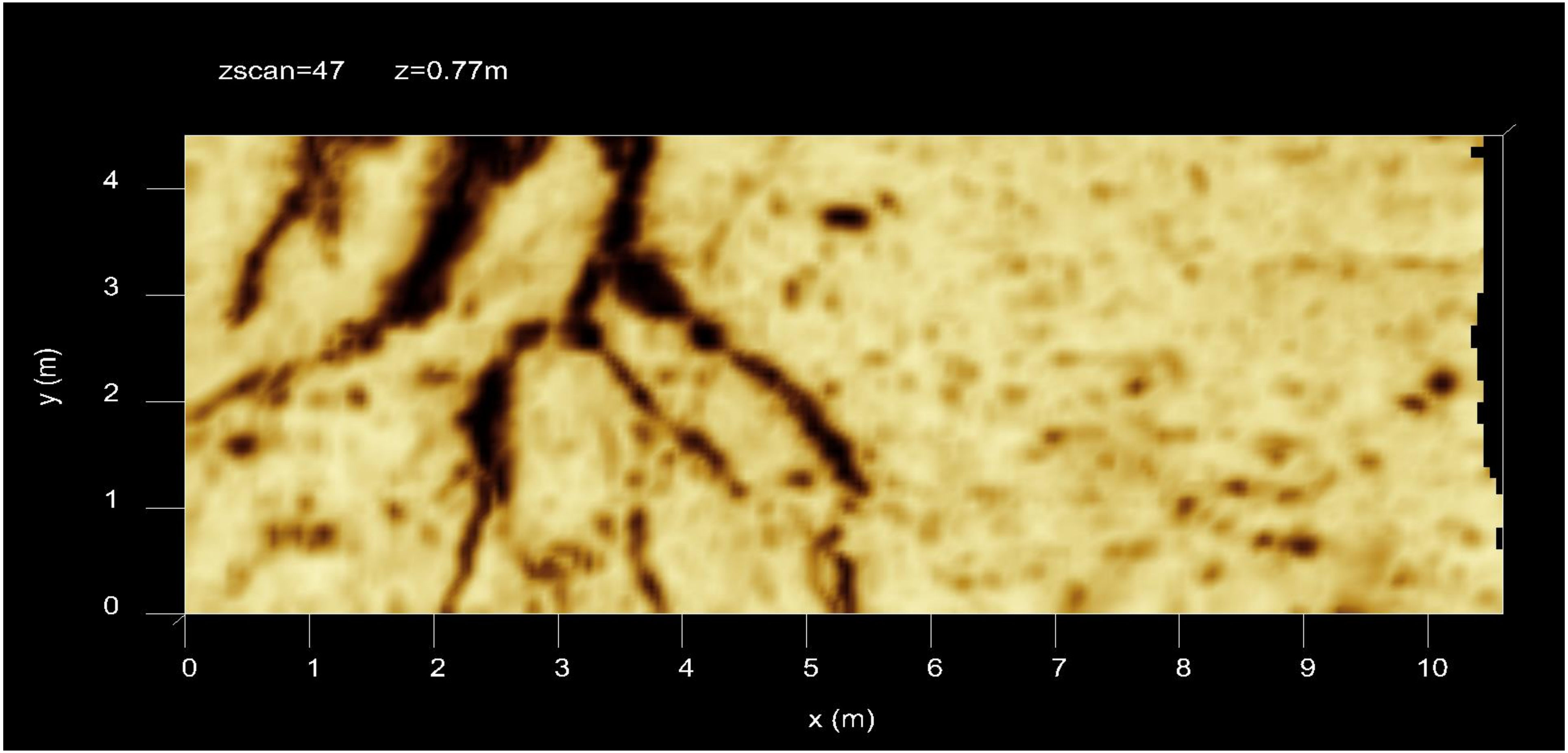
EL GEO-RADAR (GPR): APLICACIONES

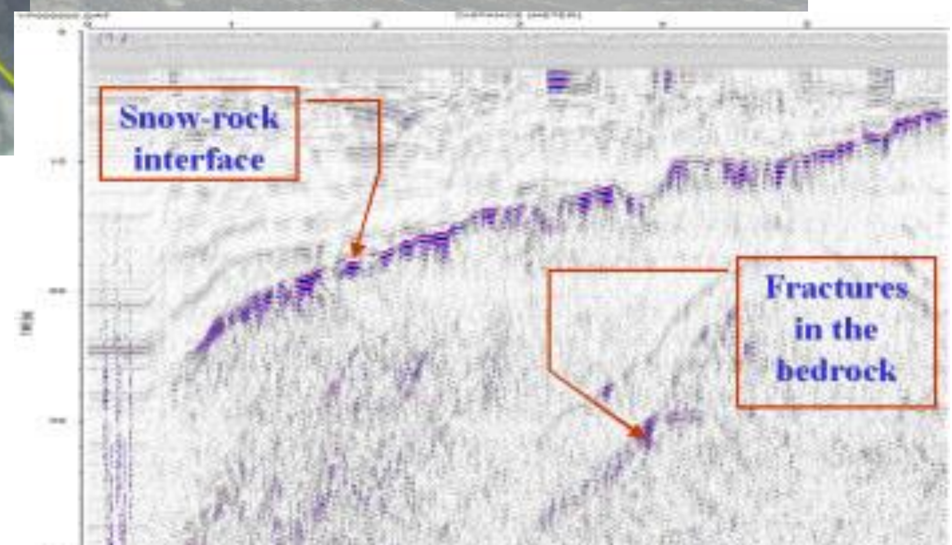


EL GEO-RADAR (GPR): APLICACIONES



EL GEO-RADAR (GPR): APLICACIONES

Exploración: Cuanto mide realmente el Everest?



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The new elevation of Mount Everest

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Alex Novo

Geosystems Business Unit Director

IDS GeoRadar
NORTH AMERICA

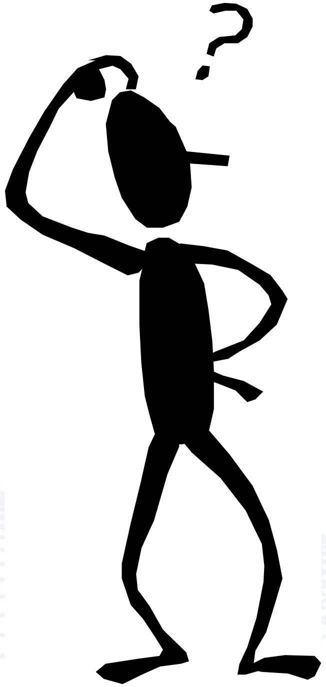
HEXAGON

Parameters of influence and performance

- Module 1: GPR theory and technics
    - Fundamentals
    - GPR principles
    - Parameters of influence and performance
    - Radar interpretation

Georadar Performance

Key questions when working with GPR



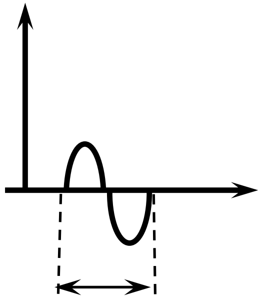
- ✓ How deep can I see?
- ✓ What's the minimum target size I can detect?
- ✓ What is the accuracy achievable by the GPR?
- ✓ What are the horizontal and vertical resolution that I can expect?

ALL THESE ASPECTS IMPACT ON THE GPR SYSTEM & SURVEY DESIGN

Parameters of influence and performance

Transmission frequency and resolution in depth

hypothesis → **TX generates a unique cycle of sinusoid with f pair to the central f of antenna**



T_0

Pulse time transmitted

F of band centre

$$f_0 = \frac{1}{T_0}$$

→

Wavelenght

$$\lambda = \frac{v}{f_o}$$

→ **Penetration depth**

Transmission band

$$B = \frac{1}{T_0}$$

→

Resolution in depth

$$r_{rg} = \frac{v}{2B}$$

→ **Image quality**

Propagation speed in the terrain

Parameters of influence and performance

Antenna properties

Low freq → Long wavelength → Bigger antenna size → Deeper penetration → Lower resolution

High freq → Short wavelength → Smaller antenna size → Shallower penetration → Higher resolution

Parameters of influence and performance

Critical zone for pipes detection

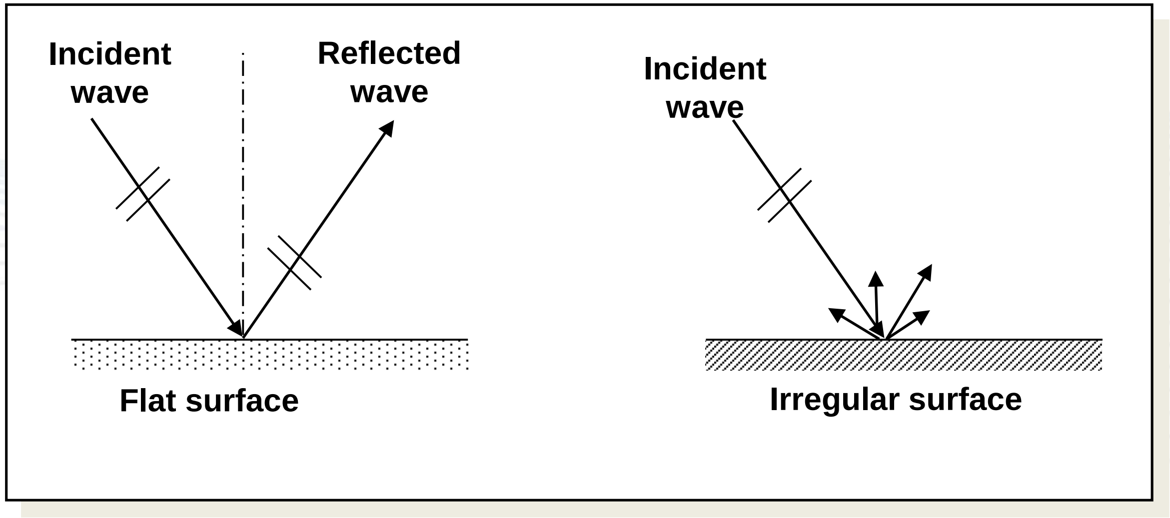
Critical zone ⇨ **Pipe radius/wave lenght < 0.1**

Below those dimensions there is an important loss of radar power

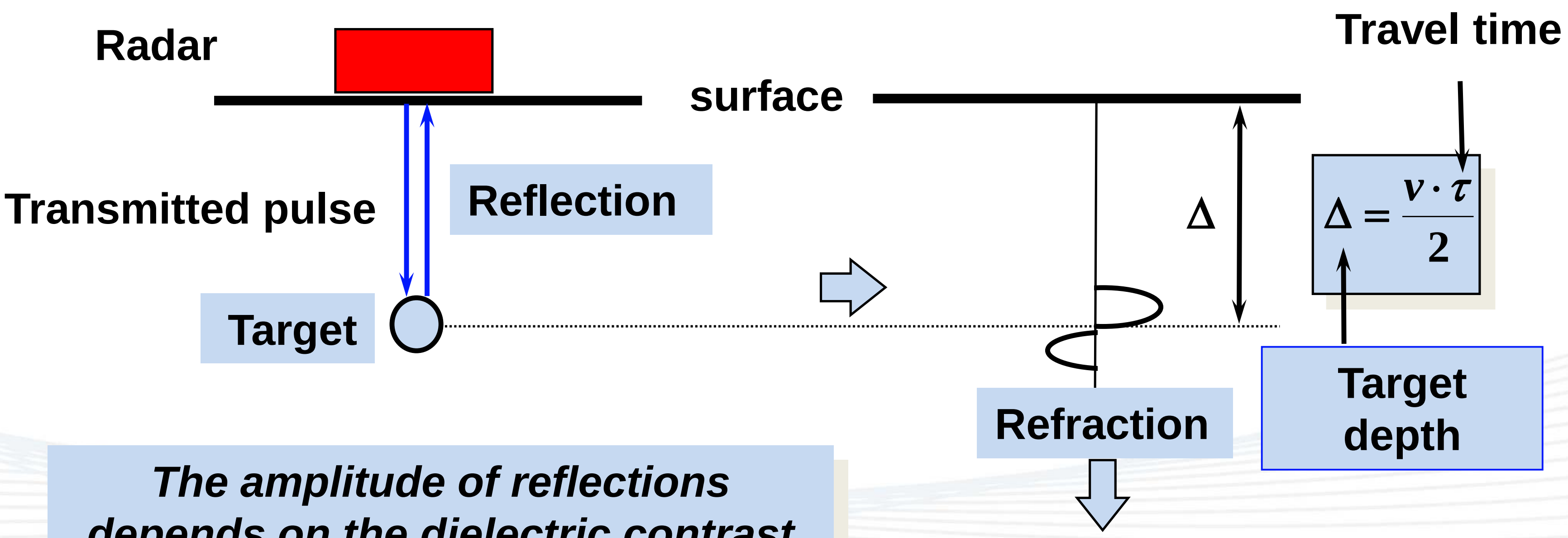
200MHz Antenna	400MHz Antenna	600MHz Antenna
⇩	⇩	⇩
Pipe radius = 5cm	Pipe radius = 2.5cm	Pipe radius = 1.25cm

Scattering of the EM waves

- *Scattering*: reflection in multiple directions.
- Scattering makes targets detection more difficult.
- Scattering can be caused by porosity, irregular dimensions/shapes of underground structures/objects.



Losing of scattering in utilities



The amplitude of reflections depends on the dielectric contrast between the target and the surrounding soil

Parameters of influence and performance

- **Electrical conductivity** The ability of a material to conduct electric current.

- **Electrical resistivity** The inverse of conductivity. This property quantifies how strongly a given material opposes the flow of electric current.

- **Electrical permittivity or Dielectric Constant** Dimensionless measure of the capacity of a material to store charge when an electric field is applied.

Parameters of influence and performance

Electrical Conductivity *siemens/meter (S/m)*

- The ability of a material to conduct electric current
- Value ranges from 4 to 10^{-9} S/m
- The opposite measure is electrical resistivity measured in ohm/meters
- The value is primarily controlled by water content and/or clay content
- Higher conductivity makes radar signal penetration difficult
  - Conductivity > .01 S/m (resistivity < 100 ohm x meters) are difficult GPR conditions

Parameters of influence and performance

GPR performance vs Electrical conductivity

- **Low conductivity** - excellent radar conditions (cond. <10^{-7}S/m)
  - air
  - dry granite, dry limestone
  - concrete, asphalt
- **Medium conductivity** - medium radar conditions (10^{-7} cond. < 10^{-2}S/m)
  - freshwater, freshwater ice, snow
  - sand, silt, dry clay, basalt, seawater ice
- **High conductivity** - poor radar conditions (cond. > 10^{-7}S/m)
  - wet clay, wet shale
  - seawater

Parameters of influence and performance

Electrical resistivity/Conductivity

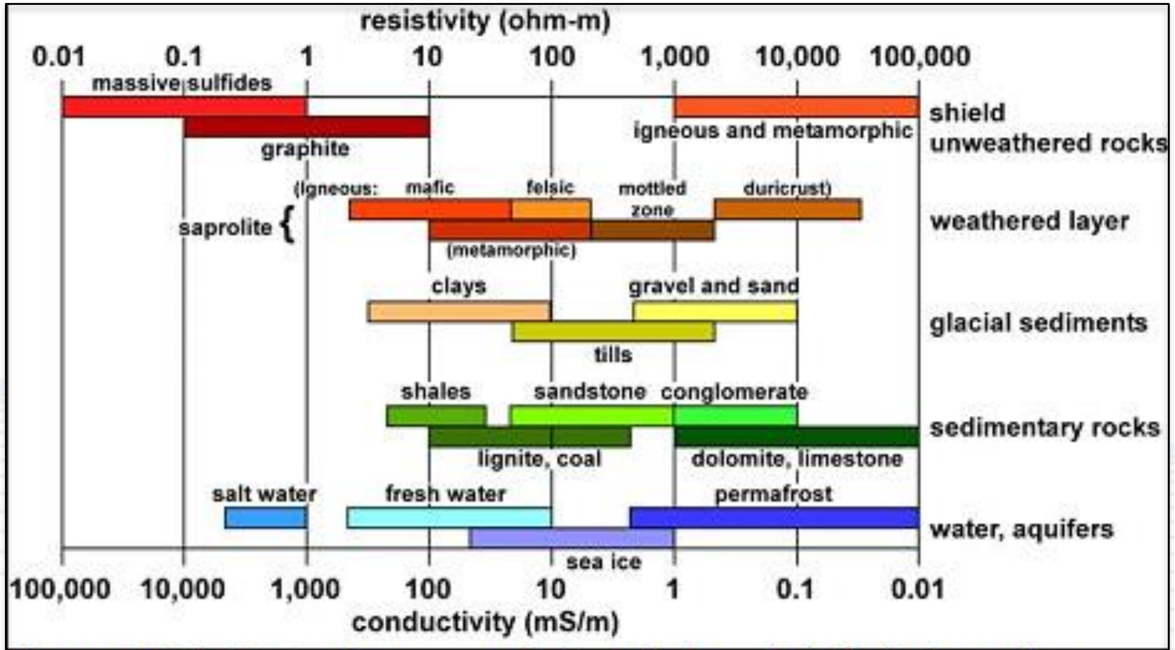


Figure 1.12. Typical ranges of electrical resistivity (ohm-m) or conductivity (mS/m) for selected Earth materials (Palacky 1988)..

MATERIAL	σ mho/m	εr
Air	0	1
Pure Water	10^{-4} to $3 \cdot 10^{-2}$	81
Seawater	4	81
Freshwater Ice	10^{-3}	4
Granite (dry)	10^{-8}	5
Limestone (dry)	10^{-9}	7
Clay (saturated)	10^{-1} to 1	8 to 12
Firn Snow	10^{-6} to 10^{-5}	1.4
Sand (dry)	10^{-7} to 10^{-3}	4 to 6
Sand (saturated)	10^{-4} to 10^{-2}	30
Silt (saturated)	10^{-3} to 10^{-2}	10
Seawater Ice	10^{-2} to 10^{-1}	4 to 8
Basalt (wet)	10^{-2}	8
Granite (wet)	10^{-3}	7
Shale (wet)	10^{-1}	7
Sandstone (wet)	4.10^{-2}	6
Limestone (wet)	$2.5 \cdot 10^{-2}$	8
Soil		
-Sandy Dry	$1.4 \cdot 10^{-4}$	2.6
-Sandy Wet	$6.9 \cdot 10^{-3}$	25
-Loamy Dry	$1.1 \cdot 10^{-4}$	2.5
-Loamy Wet	$2.1 \cdot 10^{-2}$	19
-Clayey Dry	$2.7 \cdot 10^{-4}$	2.4
-Clayey Wet	$5.0 \cdot 10^{-2}$	15
Permafrost	10^{-5} to 10^{-2}	4 to 8

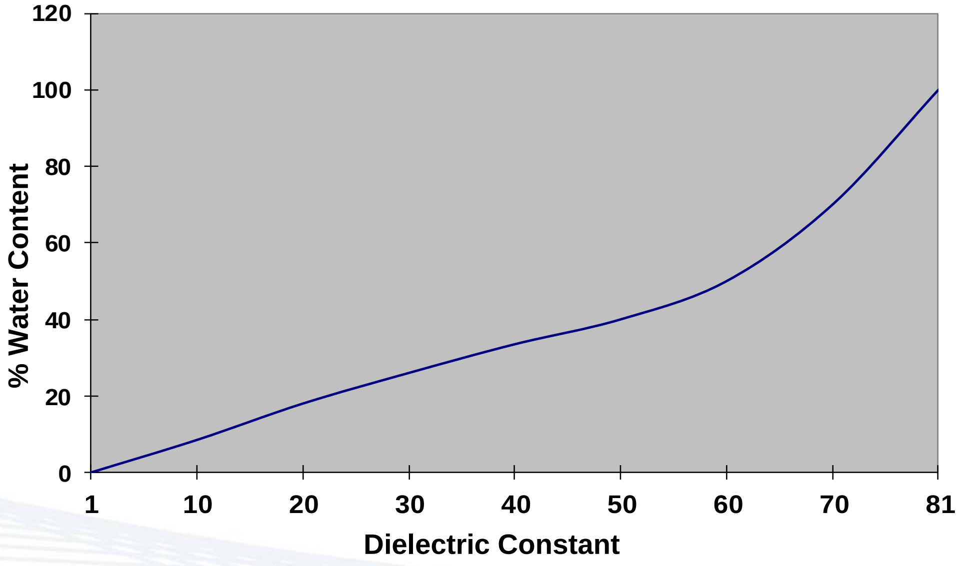
Relative Dielectric Permittivity (Dielectric Constant, εr)

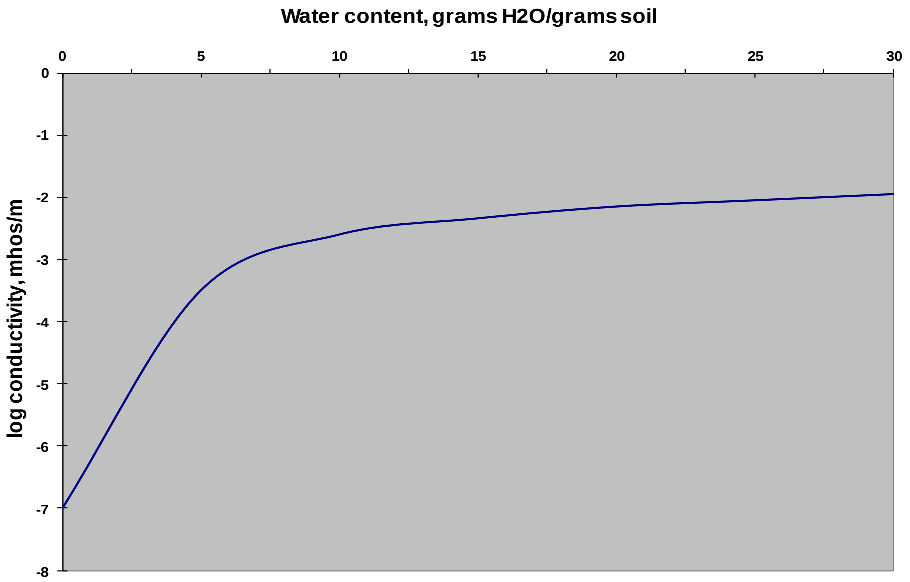
- Dimensionless parameter that measures the capacity of a material to store charge when an electric field is applied;
- The value ranges from 1 to 81 (1 = air, 81 = water);
- The value (for soils) is primarily controlled by water content
- Differences in dielectric properties between two adjacent materials through which the radar wave propagates will cause reflection of some of the radar energy back to the surface, where its amplitude and return time (two-way travel time) can be measured. The strength of reflections is controlled by the contrast in the dielectric constants of the two adjacent materials.
- Dielectric differences as small as 1 can cause reflections in GPR data.

MATERIAL	σ mho/m	εr
Air	0	1
Pure Water	10^{-4} to $3 \cdot 10^{-2}$	81
Seawater	4	81
Freshwater Ice	10^{-3}	4
Granite (dry)	10^{-8}	5
Limestone (dry)	10^{-9}	7
Clay (saturated)	10^{-1} to 1	8 to 12
Firn Snow	10^{-6} to 10^{-5}	1.4
Sand (dry)	10^{-7} to 10^{-3}	4 to 6
Sand (saturated)	10^{-4} to 10^{-2}	30
Silt (saturated)	10^{-3} to 10^{-2}	10
Seawater Ice	10^{-2} to 10^{-1}	4 to 8
Basalt (wet)	10^{-2}	8
Granite (wet)	10^{-3}	7
Shale (wet)	10^{-1}	7
Sandstone (wet)	4.10^{-2}	6
Limestone (wet)	$2.5 \cdot 10^{-2}$	8
Soil		
-Sandy Dry	$1.4 \cdot 10^{-4}$	2.6
-Sandy Wet	$6.9 \cdot 10^{-3}$	25
-Loamy Dry	$1.1 \cdot 10^{-4}$	2.5
-Loamy Wet	$2.1 \cdot 10^{-2}$	19
-Clayey Dry	$2.7 \cdot 10^{-4}$	2.4
-Clayey Wet	$5.0 \cdot 10^{-2}$	15
Permafrost	10^{-5} to 10^{-2}	4 to 8
Pvc		3
Asphalt		3-5
Concrete		4-11 (5)

Parameters of influence and performance

Effects of water content





Parameters of influence and performance

Influence of the dielectric constant on the propagation velocity

$$v = \frac{c}{\sqrt{\varepsilon_r}}$$

$$c = 3 \cdot 10^8 \, m/s$$

Average soil $v = 10^8 \, m/s$ ***(or 10cm/nsec)***

Medium	ε_r	v (cm/nsec)
Air	*1*	*30*
Water	*81*	*3*
Sand	*2.6 -25*	*19 - 6*
Lime	*2.5 - 19*	*19 - 7*
Clay	*2.4 - 15*	*19 - 8*
Wet Basalt	*8*	*11*
Wet Granite	*7*	*11*
Wet Sandstone	*6*	*12*
Wet Limestone	*8*	*11*

Parameters of influence and performance

Dielectric constant, conductivity and propagation velocity

Low Conductivity - Excellent Radar Conditions (Cond. <10^{-7} S/m): air, dry granite, dry limestone, **concrete**, asphalt.

Material	Dielectric constant	Conductivity (S/m)	Propagation velocity (m/ns)
Air	1		3,0000
Snow	1-2		0,0156
PVC (PolyVinyl Chloride)	3		1,7321
Asphalt	3-5		0,0156
Freshwater Ice	4		1,5000
Concrete	4-11 (5)		1,5000 - 0,90453 (1,3416)
Bedrock, Granite	4-7		0,0156
Sandstone	6		1,2247
Shale	5-15		0,0146
Dry limestone	4-8	Less than 10^{-7}	0,0156
Basalt	8-9		0,0156
Soils And Sediments	4-30		0,0285
Fresh And Saltwater	81		0,3333

References: *D. J. Daniels,* Ground Penetrating Radar, The Institution of Electrical Engineers, London, United Kingdom, 2005.

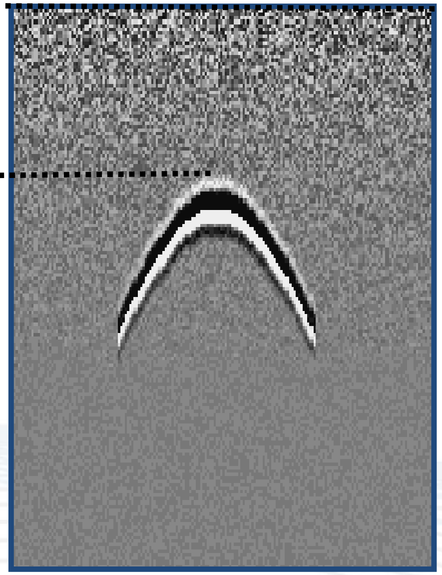
Example

$$\Delta = \frac{v \cdot \tau}{2}$$

Hyperbola fitting is commonly used to estimate the depth of targets

$\tau = 20$ nsec

Two-way travel time



Radar map

Example for $\tau = 20$ nsec

ε_r	v (cm/nsec)	Depth (cm)
1 (air)	*30*	*300*
9 (common dry soil)	*10*	*100*
16 (common wet soil)	*7.5*	*75*
81 (water)	*3.3*	*33*

Common soil : $\varepsilon_r = 9 - 16$ → **If we choose a random value in between, for example, $\varepsilon_r = 12$ (accuracy is within 10cm)**

Clutter

- A factor to consider for evaluating the performance in GPR is ***clutter***.
- In GPR *clutter* is defined as a group of reflected signals not related to «our target» (i.e., pipe) but to external sources (i.e., stones) with similar characterics.
- The higher the *clutter*, the harder the radar map interpretation becomes.

The resolution /1

❖ **Plan resolution (horizontal resolution) is the capability of the radar to distinguish close targets at the same depth.**

❖ **Radar antenna transmits a cone of energy into the subsurface. Majority of the reflected energy comes from the center area of the cone, called the first Fresnel zone**

❖ **The radius of the first Fresnel zone which radius R_0 can be approximated as**

$$R_o = \frac{\lambda}{4}\sqrt{1+(8r/\lambda)} \cong \sqrt{r\lambda/2}\text{, assuming that } r>>\lambda$$

where
λ is the wavelength
r is the depth to the target.

The higher the GPR antenna frequency the better the plan resolution

The resolution /2

❖**Depth resolution** (vertical resolution) is the capability to distinguish between the various targets in range. For a bandwidth-limited system it is given by the following equation:

$$\Delta R = \frac{c}{2B\sqrt{\mu_r \varepsilon_r}}$$

ΔR = Resolution
c = Velocity of electromagnetic radiation in free space
B = Bandwidth
μ_r = Relative permeability of the transmission medium
ε_r = Relative permittivity of the transmission medium

The higher the GPR antenna frequency the better the depth resolution and the lower the penetration capabilities.

The Range Depth

- **Decreases as:**
  - ✓ **Electrical Conductivity Increases**
  - ✓ **Water Content Increases**
  - ✓ **Clay Content Increases**
  - ✓ **Scattering Increases**
  - ✓ **Conductive Contaminant Increases**

GPR user has no control over the above factors. These are site specific characteristics

- **Increases as:**
  - ✓ **Antenna Frequency Decreases**
  - ✓ **Receiver Sensitivity Increases (Stacking)**
  - ✓ **Transmitter Power Increases (but it may be not compatible with regulations like FCC)**

GPR user has control over the above factors to some degree

The GPR accuracy of location

Horizontal accuracy: the GPR uses an encoder to measure distancies. Inaccuracies can be due

- **to the errors due to the encoder itself (User should ALWAYS calibrate the odometer wheel before starting scanning)**
- **to the errors due to georeference survey methods used**

Anyway, a few centimetres accuracy can be assured.

Vertical accuracy: the GPR is capable to measure a time of flight. Inaccuracies can be due to the time/depth conversion that requires an accurate evaluation of the propagation velocity in the medium.

Choosing a wrong value for the propagation velocity, may largely affect the vertical accuracy!

How to evaluate the propagation velocity

- From objects of known depth (manhole measurements, ground-truth, other)
- Hyperbola fitting (by using geometric relationship between antenna beamwidth and subsurface target data an averaged value of the velocity can be obtained)
- Standard velocities (published dielectric properties, velocities, 2-way travel times), but it is more prone to errors
- Other, less common methods (CMP, WARR)

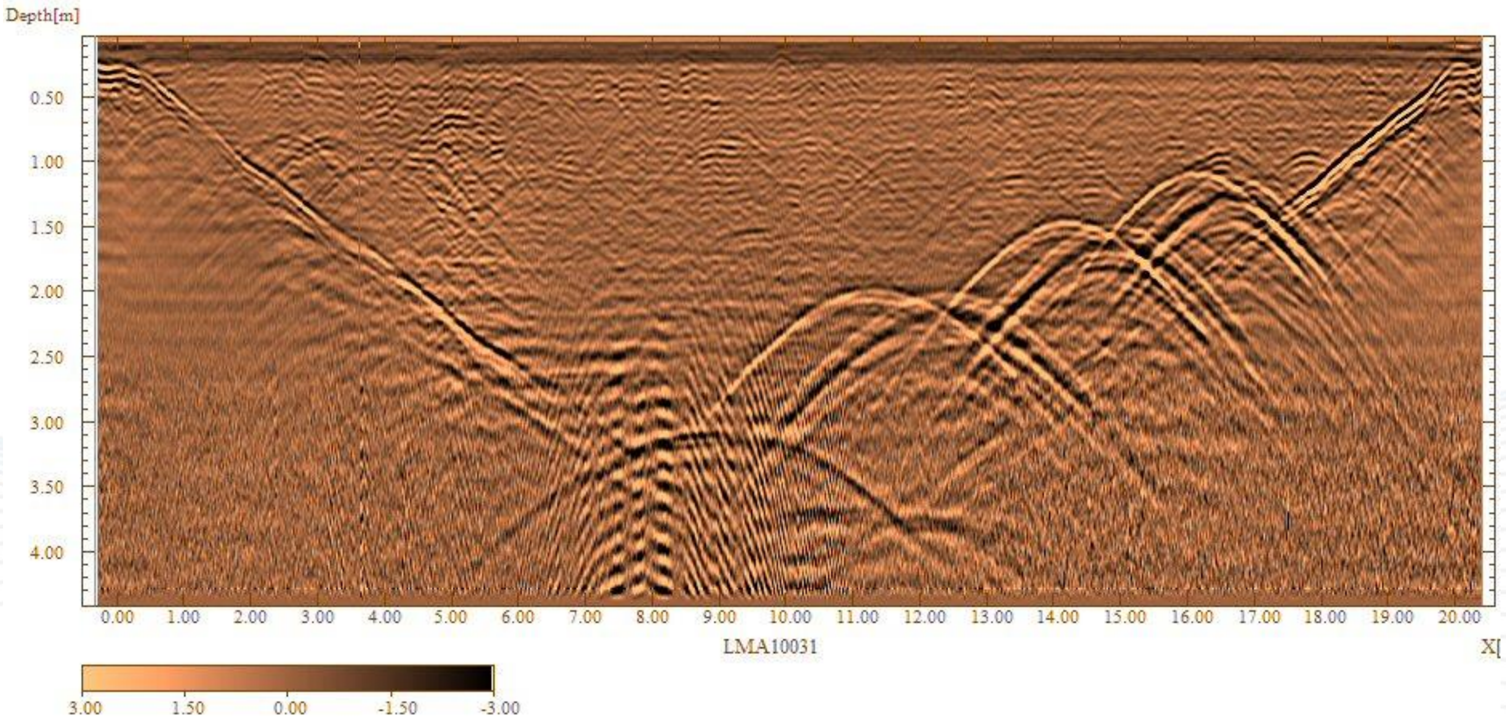
Radar map interpretation

- Module 1: GPR theory and technics
  - Fundamentals
  - GPR principles
  - Parameters of influence and performance
  - **Radar map interpretation**

Never estimate diameter!

Propagation velocity (soil conditions) affects hyperbolas' shapes

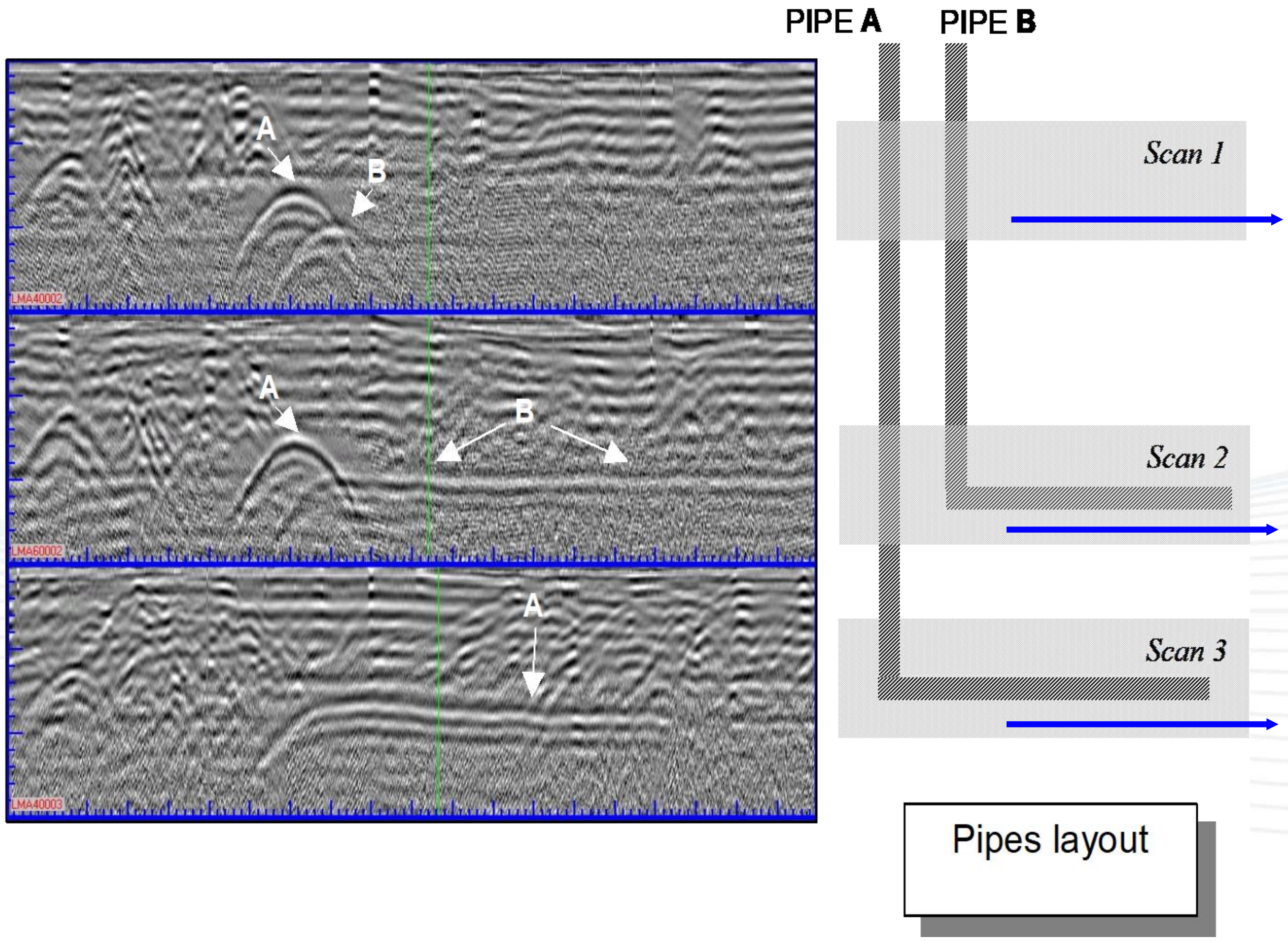
Deeper targets usually have wider aperture due to beam width (see example below)



The aperture of the hyperbola and its pick's amplitude value are related to:

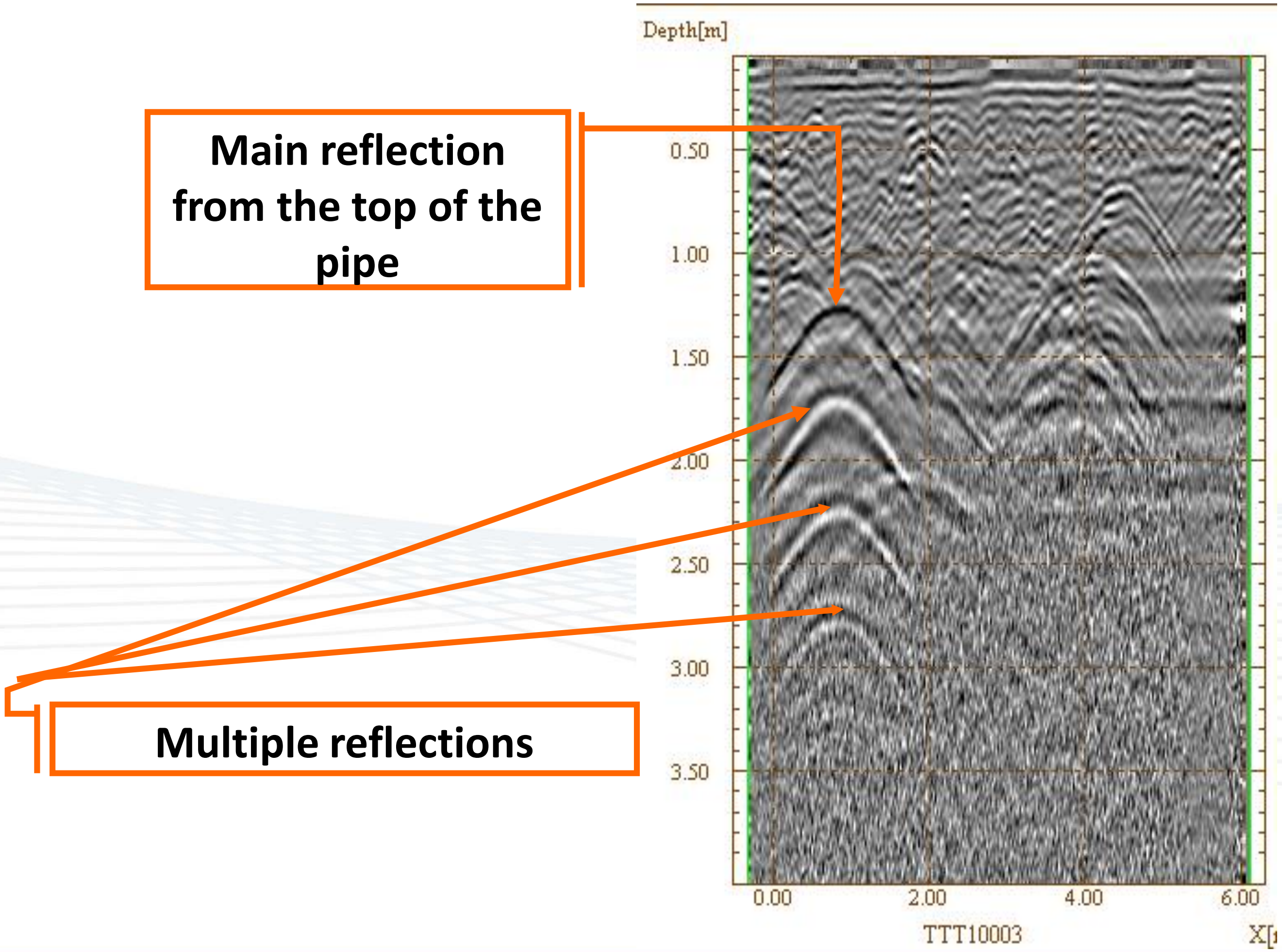
1. The dielectric constant of the material (propagation velocity of the signal)
2. The depth of the target

Reconstruction of pipes layout from parallel scans

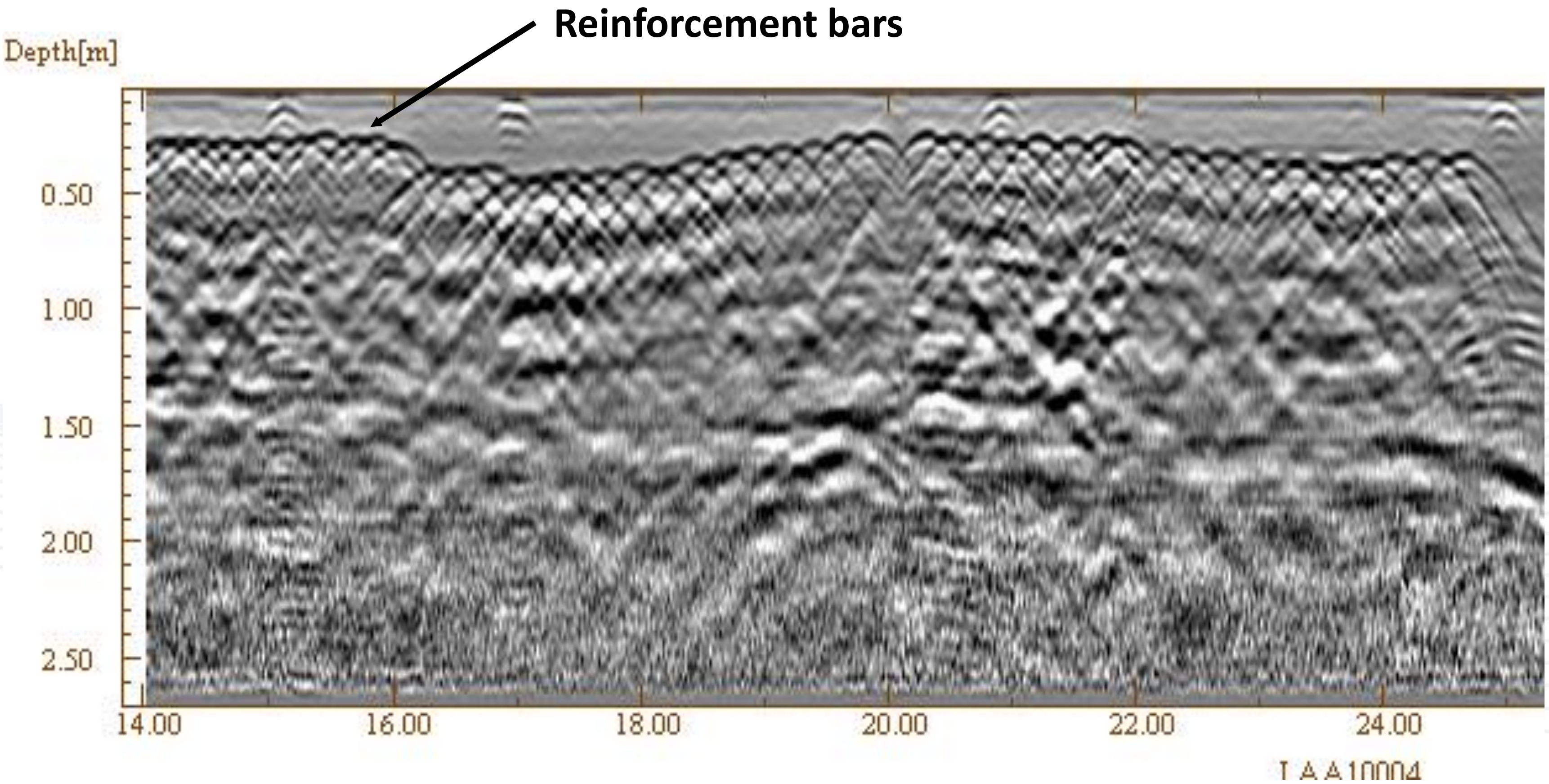


In order to determine the pipelines layout, several parallel scans have to be performed

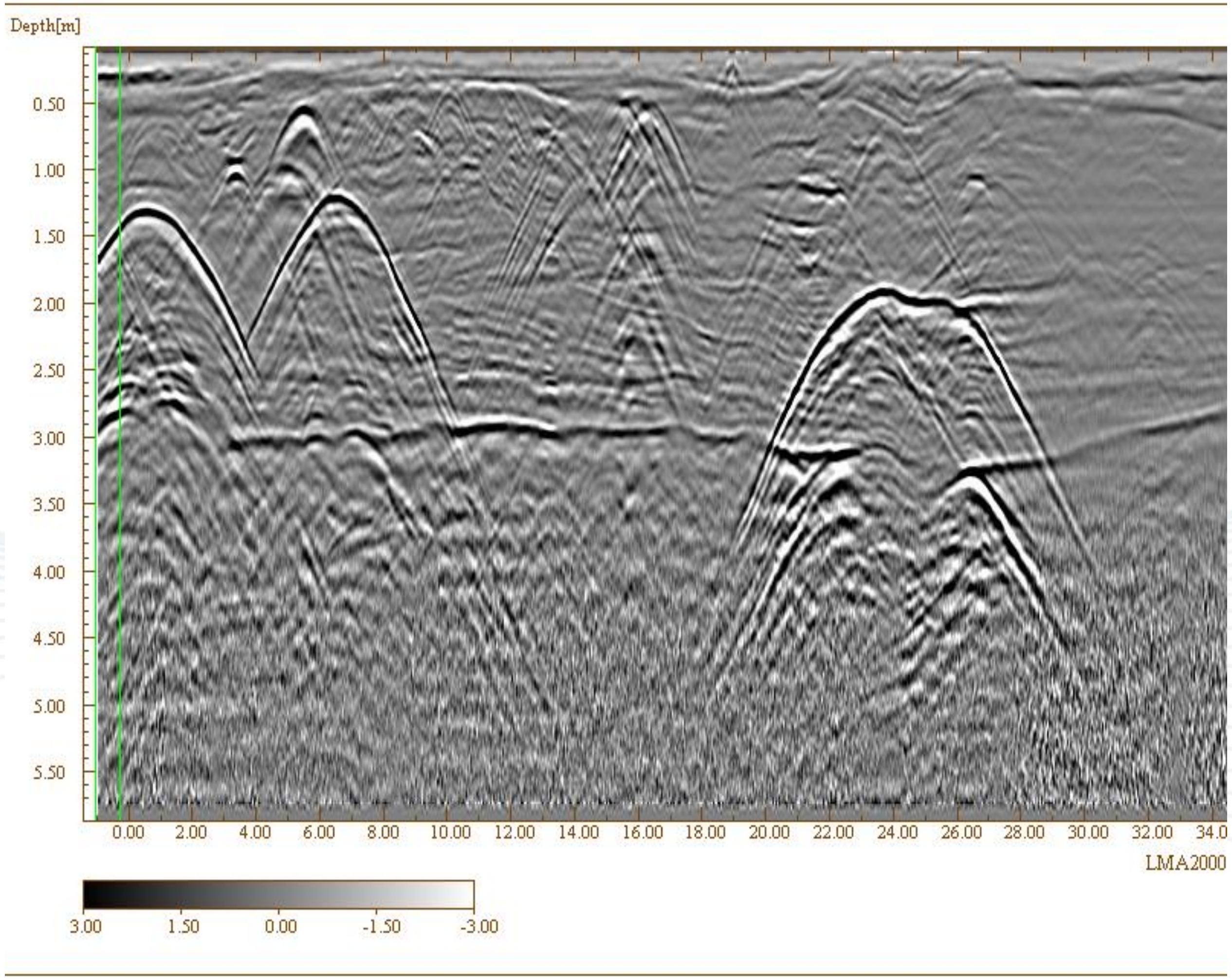
The effect of multiple reflections from a pipe



Imaging of a reinforced concrete slab

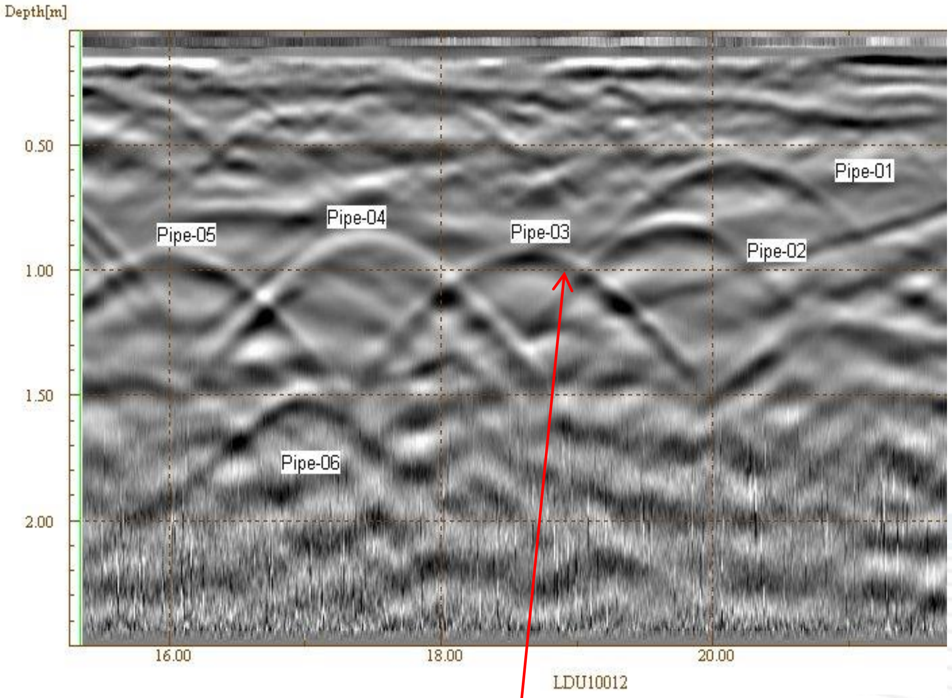


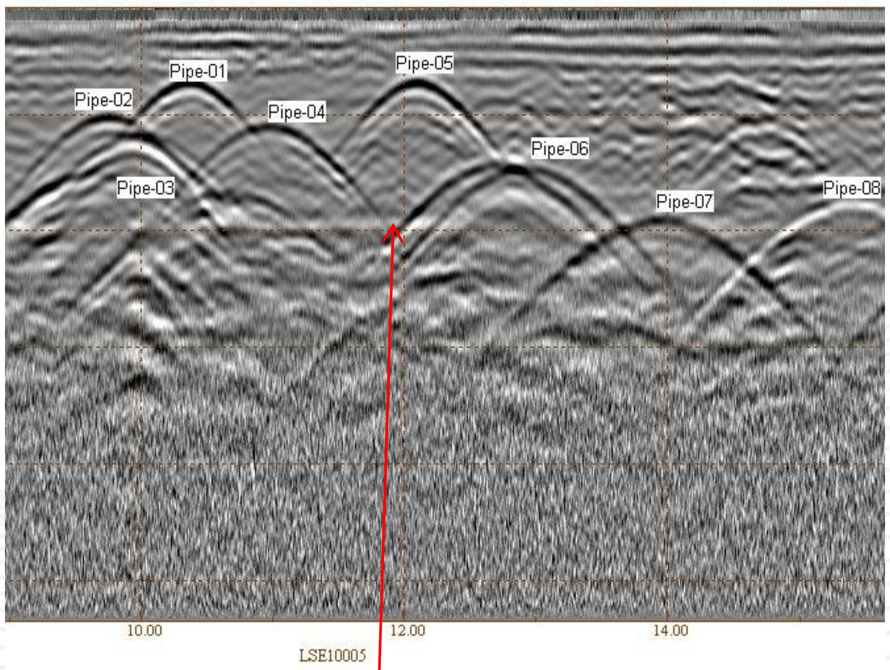
Example of pipes and geological layers on sandy soil



Radar map interpretation

Frequency vs Resolution



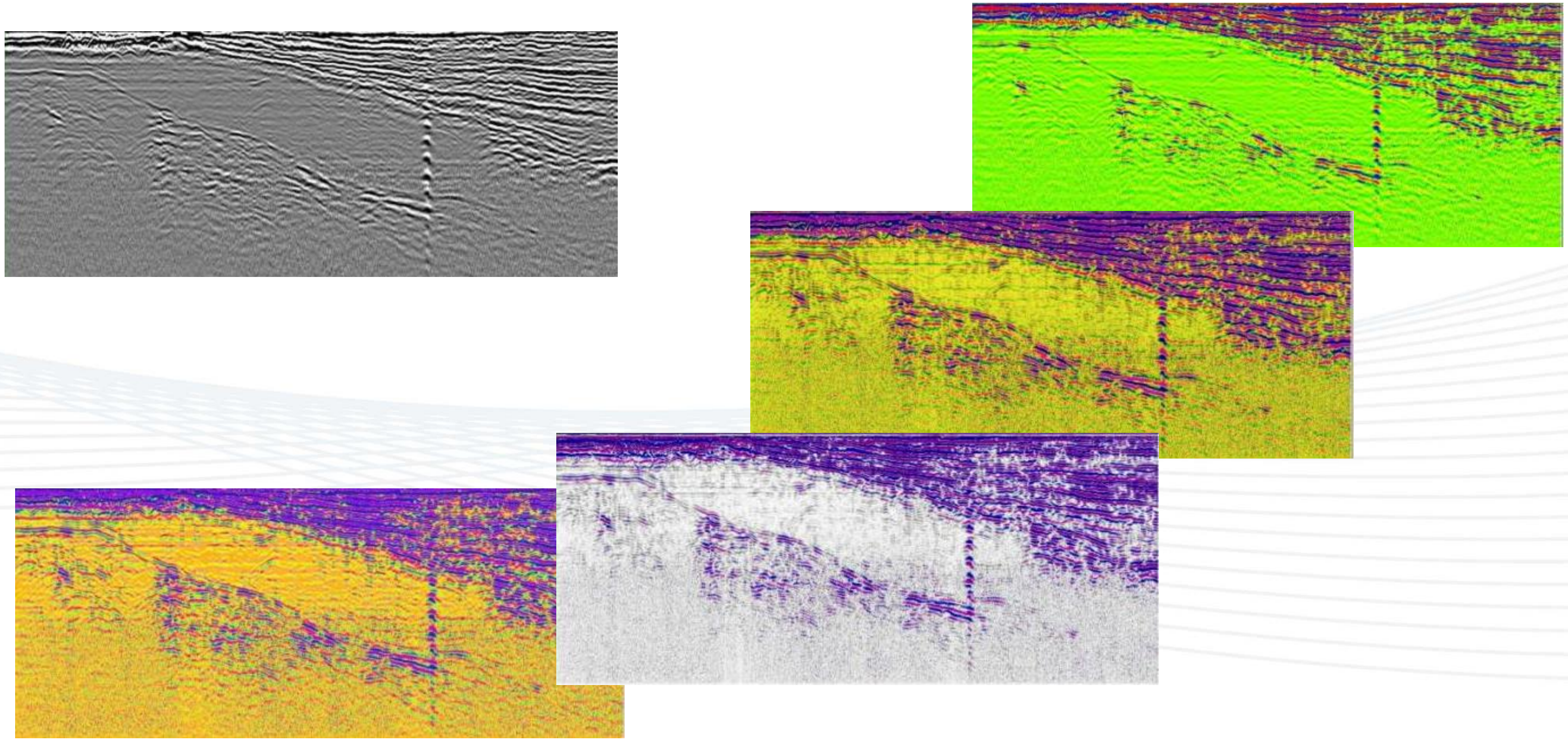


Low frequencies

High frequencies

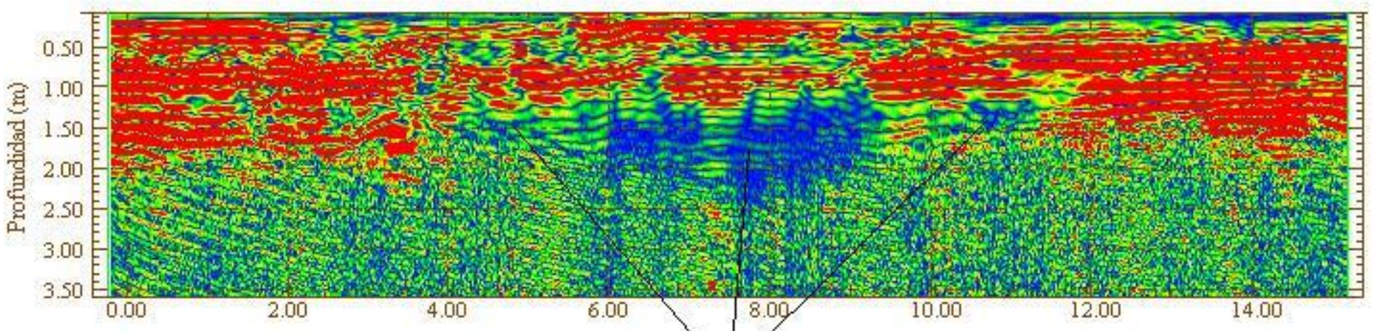
Radar map interpretation

The use of different color palettes may sometimes enhance target imaging

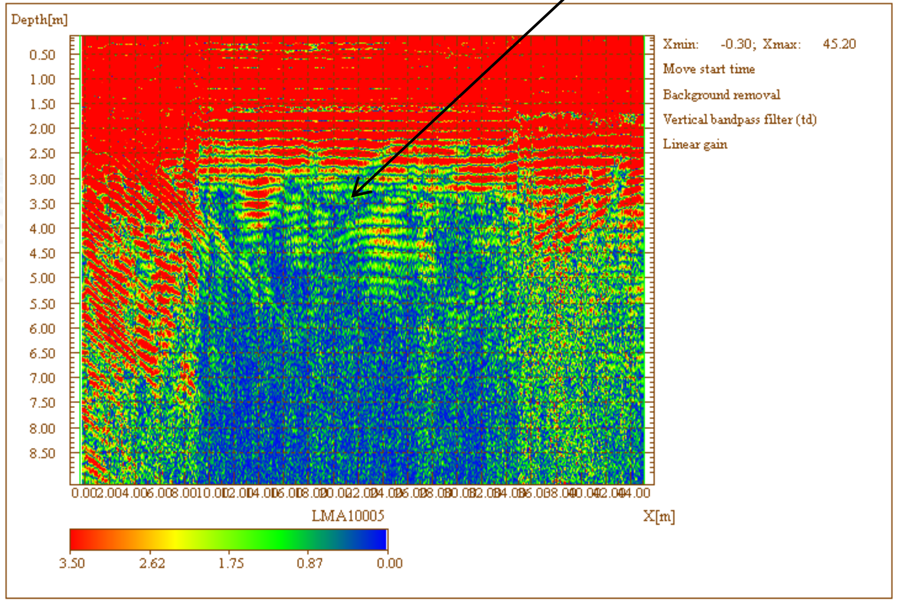


Radar map interpretation

Detection of contaminants

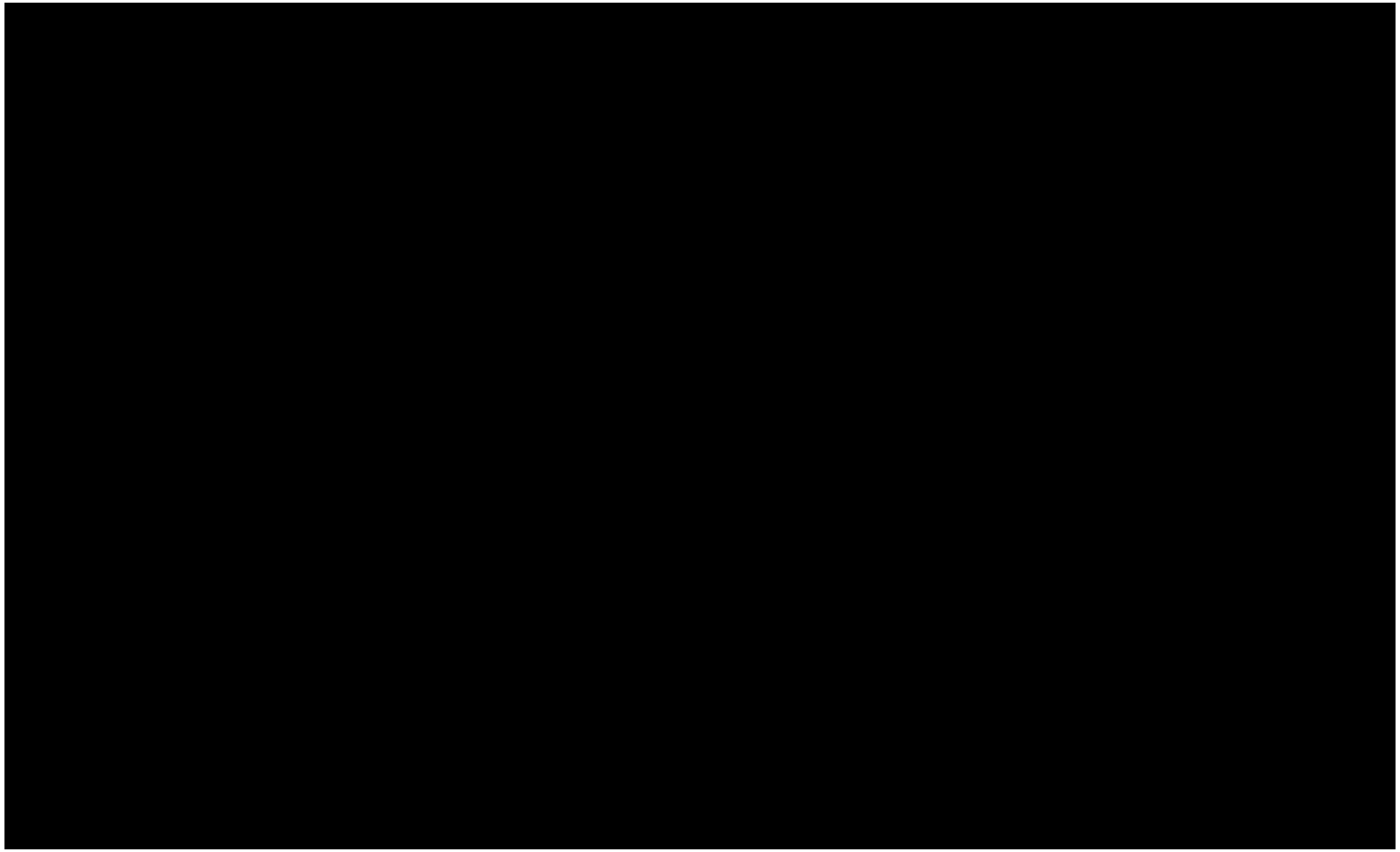


Contaminated areas



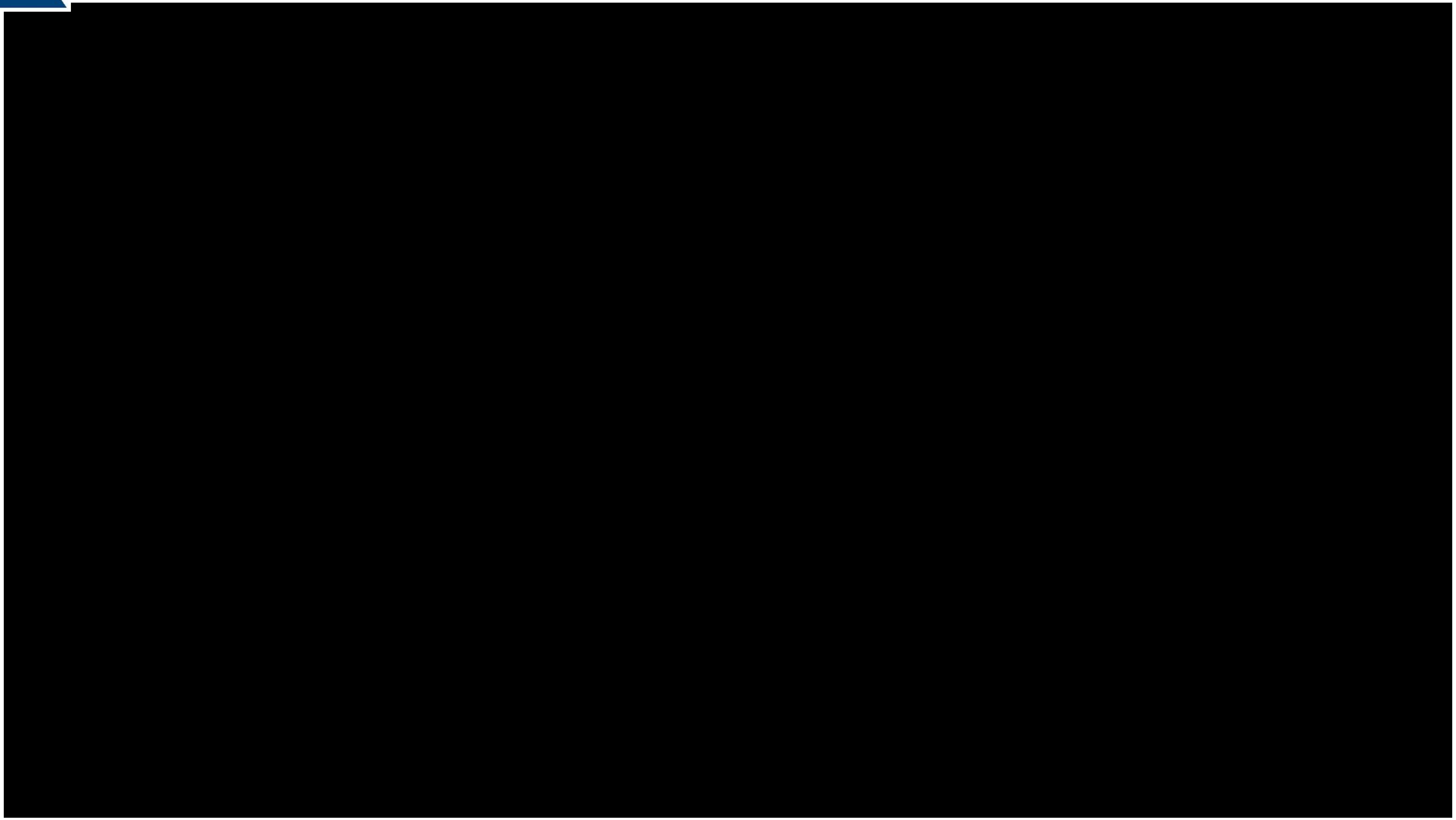
DATA POSITIONING

NAVIGATION AND REAL-TIME DEPTH-SLICE VISUALIZATION



DATA POSITIONING

SOLUTION

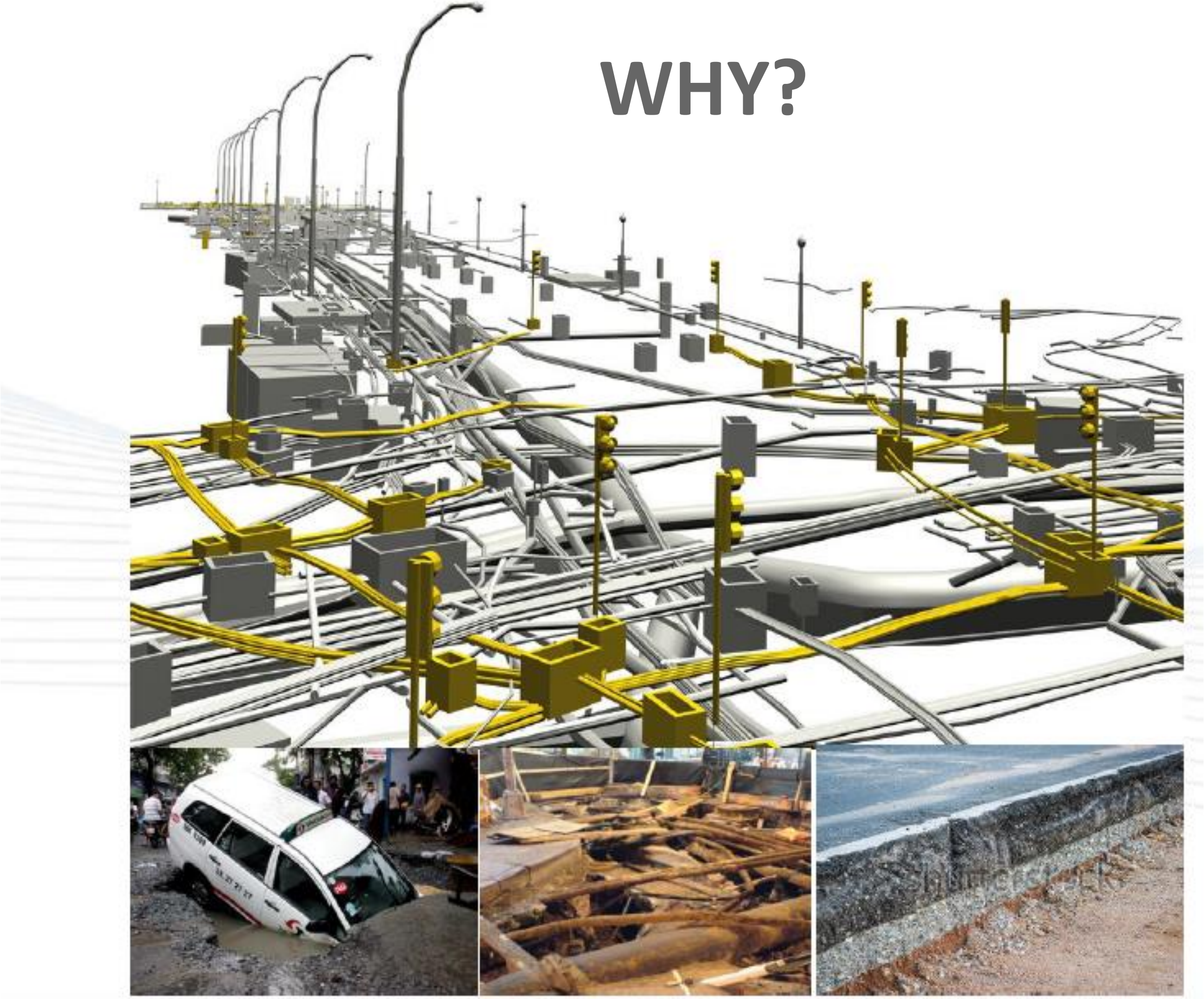


PART OF HEXAGON

GeoSystems

Underground utility locating and mapping

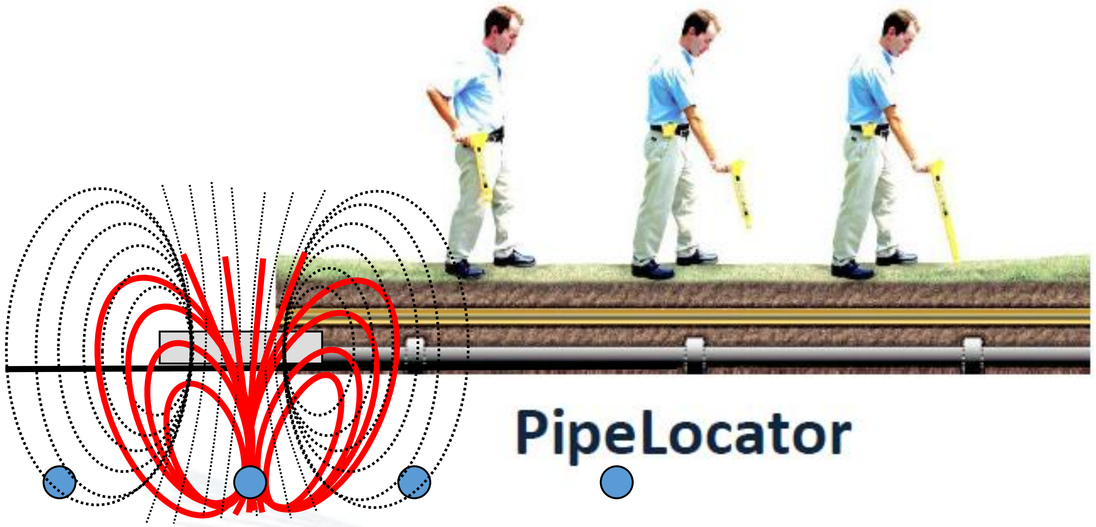
WHY?



Mapping of underground assets:

- as-built situation (pipes and cables);
- construction and utility planning (pipes and cables);
- road maintenance and renewal (roadbed conditions);
- safety (roadbed and cavities);
- other underground assets and conditions (new constructions).

Available technology for utilities detection



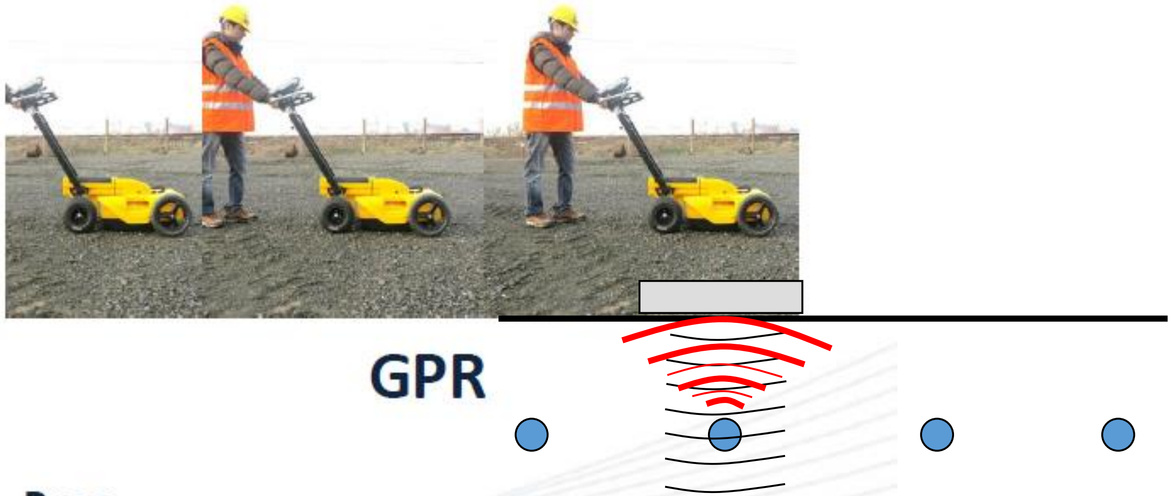
PipeLocator

Pros:

- Easy to use
- Small dimension
- Low cost

Cons:

- Locate only metallic pipe
- Affected by EM noise
- No mapping



GPR

Pros:

- Can locate any material pipes
- Defines exact position and depth
- Mapping

Cons:

- Dimension and weight
- Trained operator
- More expensive technology

Hardware Features

Self contained design

- No exposed cables
- Internal battery and wheel encoders
- Adjustable antenna height
- Foldable handle for transport

Hardware Features

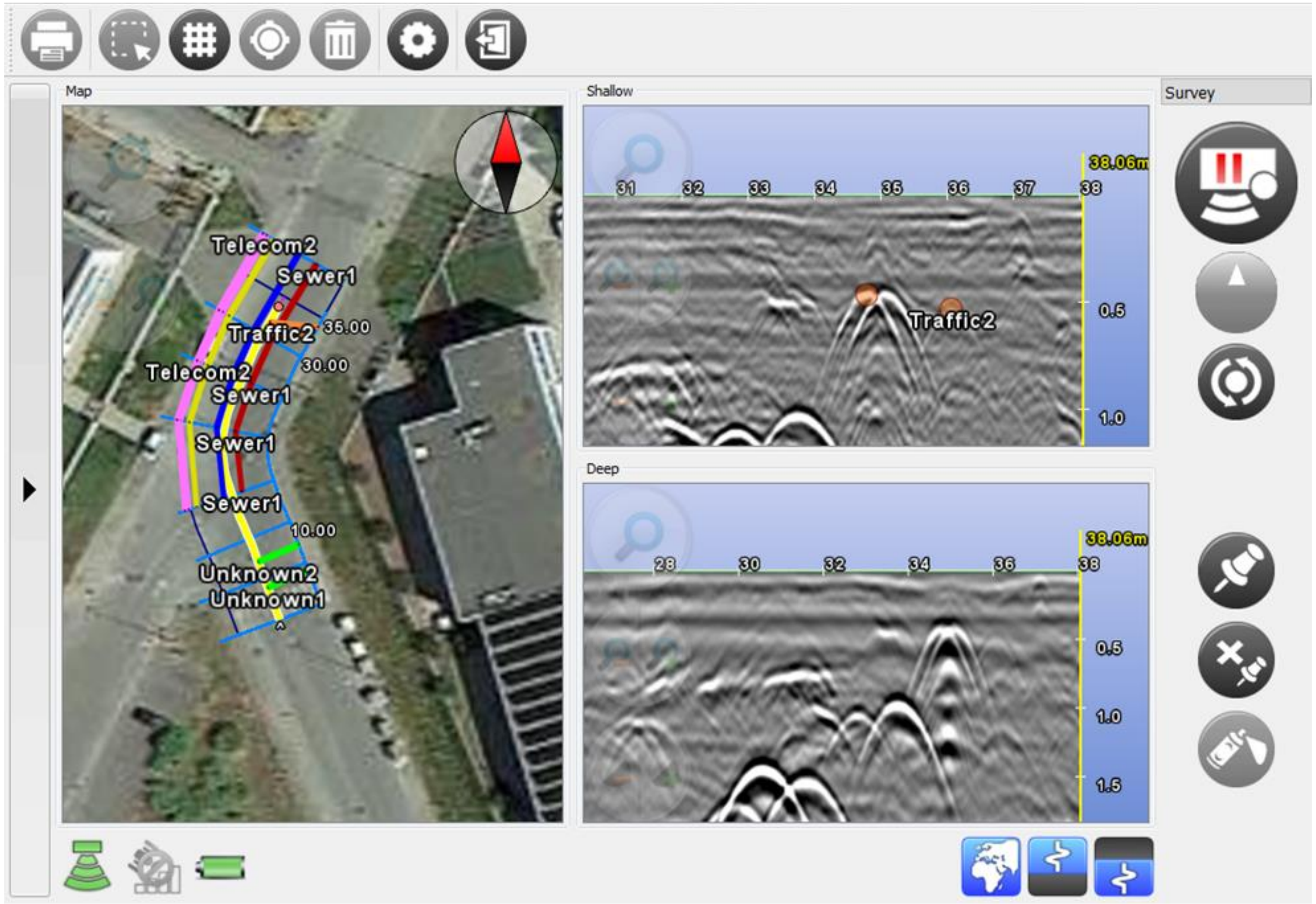
Pivoting head

The head of the Opera DUO pivots in both directions, letting the antenna stay in contact with the ground in almost any condition.

Data acquisition Software Features

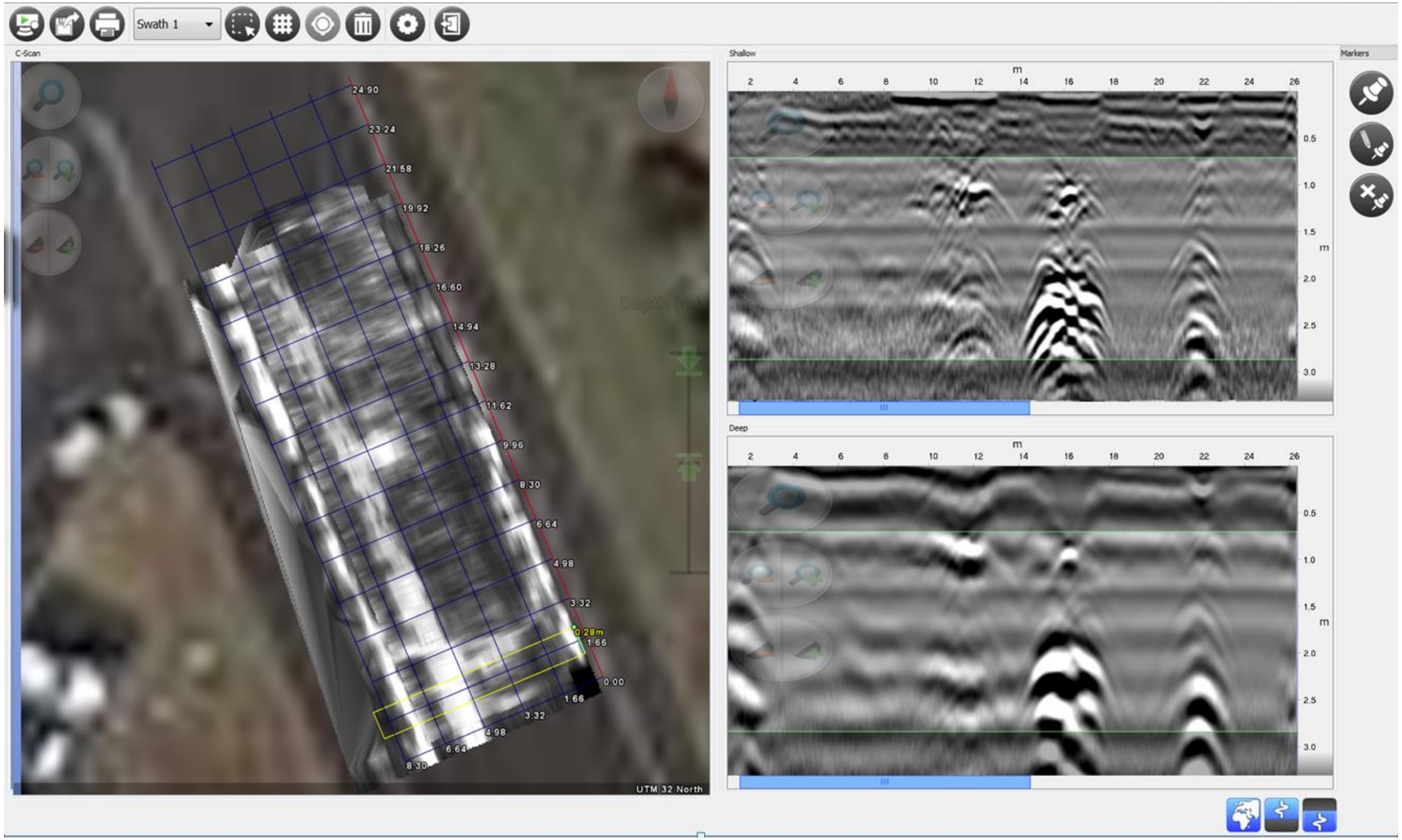
Intuitive interface (touchscreen compatible)

Satellite image, real-time GPS and/or GPR track and targets



Data acquisition Software Features

Automatic on site 3D imaging



OPERA DUO

Get accurate data collecting information from many technologies

Dedicated EML marker

Any GNSS and/or TPS

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uNext Accurate Data

OPERA DUO

Facilitate end user in data interpretation of the buried utilities

Real time tomography of the underground utility network.

Camera for visual information of recorded soil objects *

Augmented Reality to visualize underground objects in augmented reality*

PART OF HEXAGON

(*)soon available

WHY GPR? WHY SUE?

ROI of up to $21 per $1 invested

The use of GPR feeds important data into subsurface utility engineering* processes to improve the reliability of subsurface information and geolocation accuracy of buried utilities. There is growing evidence that the use of SUE in infrastructure projects has a positive return on investment.

U.S. Department of Transportation – ROI of $4.62 per $1.00 invested *'Cost Savings on Highway Projects Utilizing Subsurface Utility Engineering' (Purdue University, 1999)*

Ontario Sewer and Watermain Contractors Association – ROI of $3.41 per $1.00 invested *'Subsurface Utility Engineering in Ontario: Challenges and Opportunities' (University of Toronto, 2005)*

University of Toronto – ROI of $2.05 to $6.59 per $1.00 invested *'Evaluating the use of Subsurface Utility Engineering in Canada' (University of Toronto, 2006)*

Pennsylvania DOT – ROI of $21.00 per $1.00 invested *'Subsurface Utility Engineering Manual' (Pennsylvania State University, 2007)*

*Subsurface Utility Engineering (SUE)

GPR is a well proven non-destructive geophysical method for the detection and mapping of subsurface infrastructure. Subsurface utility engineering (SUE) professionals routinely use GPR to collect important data concerning the presence and layout of buried utilities and other subsurface assets and infrastructure.

Common Ground Alliance (CGA) report estimates more than 1.5 billion dollars in cost of utility damage to US in 2016. Approximately 379,000 incidents, 20% more than the previous year.

Legislation & Standards: Many countries have deemed the use of GPR a mandatory requirement for such work, which is supported through the implementation of robust standards such as: AS 5488-2013 (Australia), S250 (Canada), NTE INEN 2873 (Ecuador), Malaysia Standard Guideline for Underground Utility Mapping, PAS 128 (UK) and ASCE 38-02 (US).

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WHY GPR? WHY SUE?

2016 DIRT Report Interactive Analysis

CGA Common Ground Alliance · DIRT Damage Information Reporting Tool · 811 Know what's below. Call before you dig.

- The report states that **US$1.5 billion** is a conservative estimation of the societal costs associated with the damage to buried utilities; it is the first time that CGA has estimated a monetary figure of this kind.

CGA's *2016 Damage Information Reporting Tool (DIRT) Report*, which has summarized anonymously submitted data from facility operators, utility locating companies, one call centers, contractors, and regulators throughout the previous calendar year, estimated the total number of underground excavation damages in the US last year rose by 20 per cent to approximately 379,000 incidents.

https://www-trenchlessinternational-com.cdn.ampproject.org/c/s/www.trenchlessinternational.com/2017/08/28/cga-report-estimates-cost-utility-damage-us/amp/

WHY GPR? WHY SUE?

Alberta | Atlantic | British Columbia | Ontario | Quebec | Saskatchewan

National Report on Damage to Underground Infrastructure

DAMAGE PREVENTION SYMPOSIUM

CCGA

Canadian Common Ground Alliance

Highlights 2014, 2015 and 2016

The Common Ground Alliance (CGA) created the Damage Information Reporting Tool (DIRT) in 2003 to document damages to underground infrastructure. Six Canadian regions currently report damages to the CCGA's Damage Reporting and Evaluation Committee.

INTERPRETING THE DATA

This report contains preliminary findings for 2016. A comprehensive report will be published online in October.

- Reporting in DIRT is voluntary; therefore, the data analyzed is not representative of all damages that have occurred.
- Percentages are calculated on totals of reported damages omitting data where the response was "not collected".

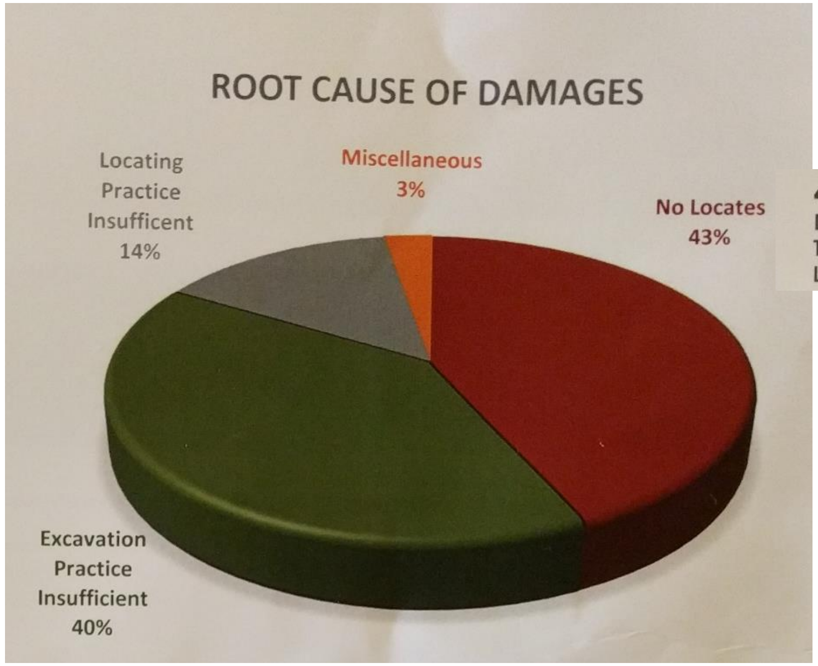
	Number of reported damages			Damages per business day*			Population	Damages per 1,000 locate requests	Damages per 1,000 notifications
	2014	2015	2016	2014	2015	2016	2016**		
Alberta	2,934	2,645	4,356	12	10.4	17.1	4,252,900	10.8	2.7
Atlantic	-	21	17	-	0.8	.07	2,385,000	1.0	0.6
B.C.	1,315	1,131	1,270	5	4.5	5.0	4,751,600	7.0	1.6
Saskatchewan	682	788	632	3	3.1	2.4	1,150,600	4.8	1.6
Ontario	3,809	4,434	4,563	15	17.5	17.9	13,413,700	4.6	0.6
Quebec	1,198	1,088	1,151	5	4.8	4.5	8,326,100	5.0	2.2
TOTAL	**9,938**	**10,107**	**11,989**	**40**	**40**	**47**	**34,279,900**	**6.3**	**1.0**

* 254 business days per year **Source: Statistics Canada

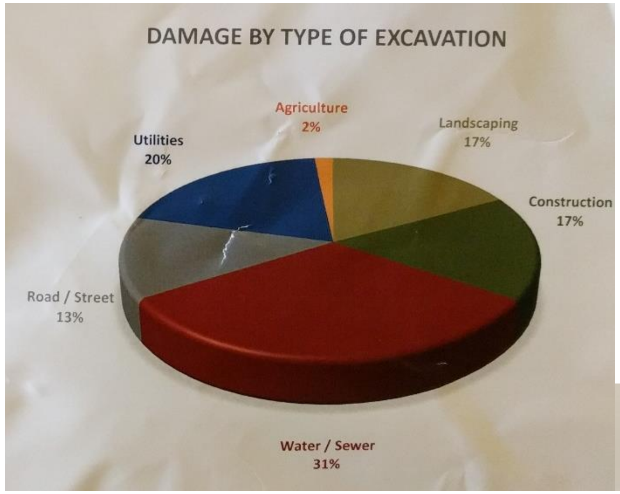
2016 AT A GLANCE

SOCIETAL COSTS IN CANADA WERE ESTIMATED AT $975 MILLION.

WHY GPR? WHY SUE?



43% OF DAMAGES WERE THE RESULT OF NO LOCATES



31% OF DAMAGES OCCUR DURING WATER/SEWER WORK

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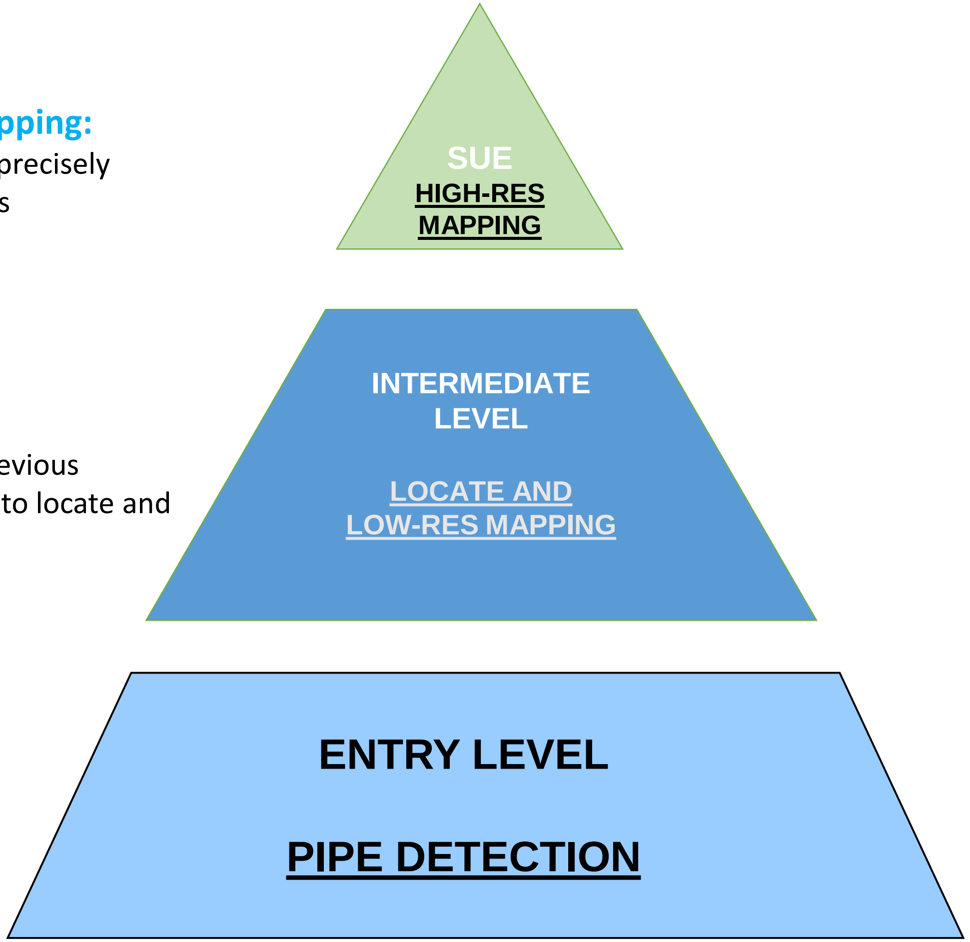
WHY GPR? WHY SUE?

Common Utility Detection and Mapping Solutions

3- Large-scale Utility Mapping:
SUE companies that want to precisely map the underground utilities

2- GPR Surveyors:
Surveying companies with previous experience in GPR who want to locate and record pipe lines

1- Starters:
Surveying companies, excavating companies who wants to detect pipes in real time before excavation.



PART OF HEXAGON

Alex Novo

IDS GeoRadar North America Geosystems Business Unit Director

HEXAGON

Alex Novo

Geosystems Business Unit Director

IDS
GeoRadar
NORTH AMERICA

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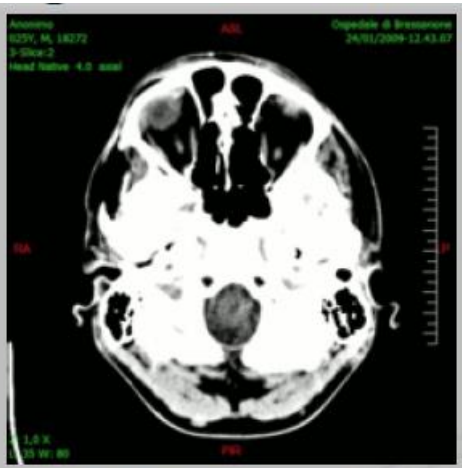
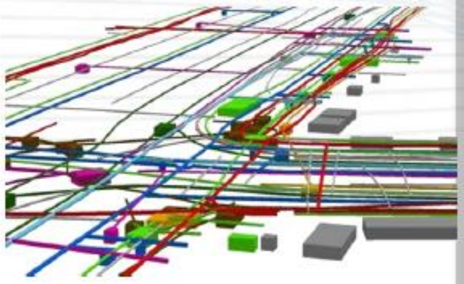
WHY MCGPR?

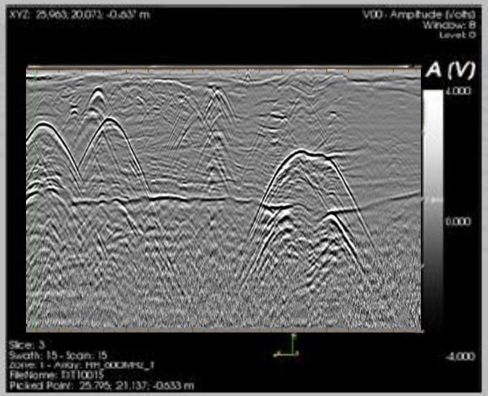
Radiography



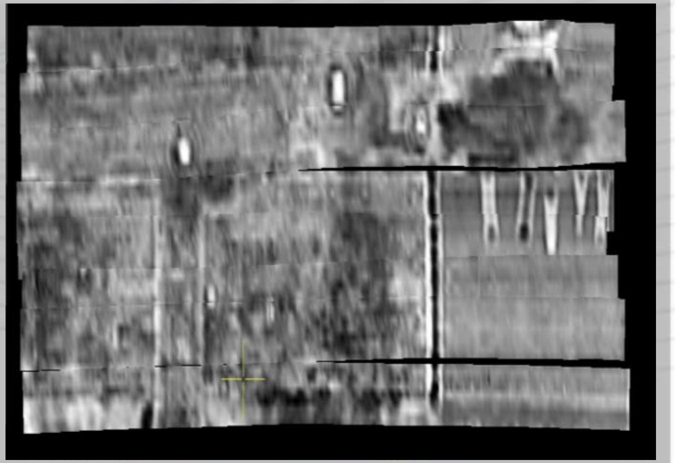
CAT (Tomography)

From detection to mapping...



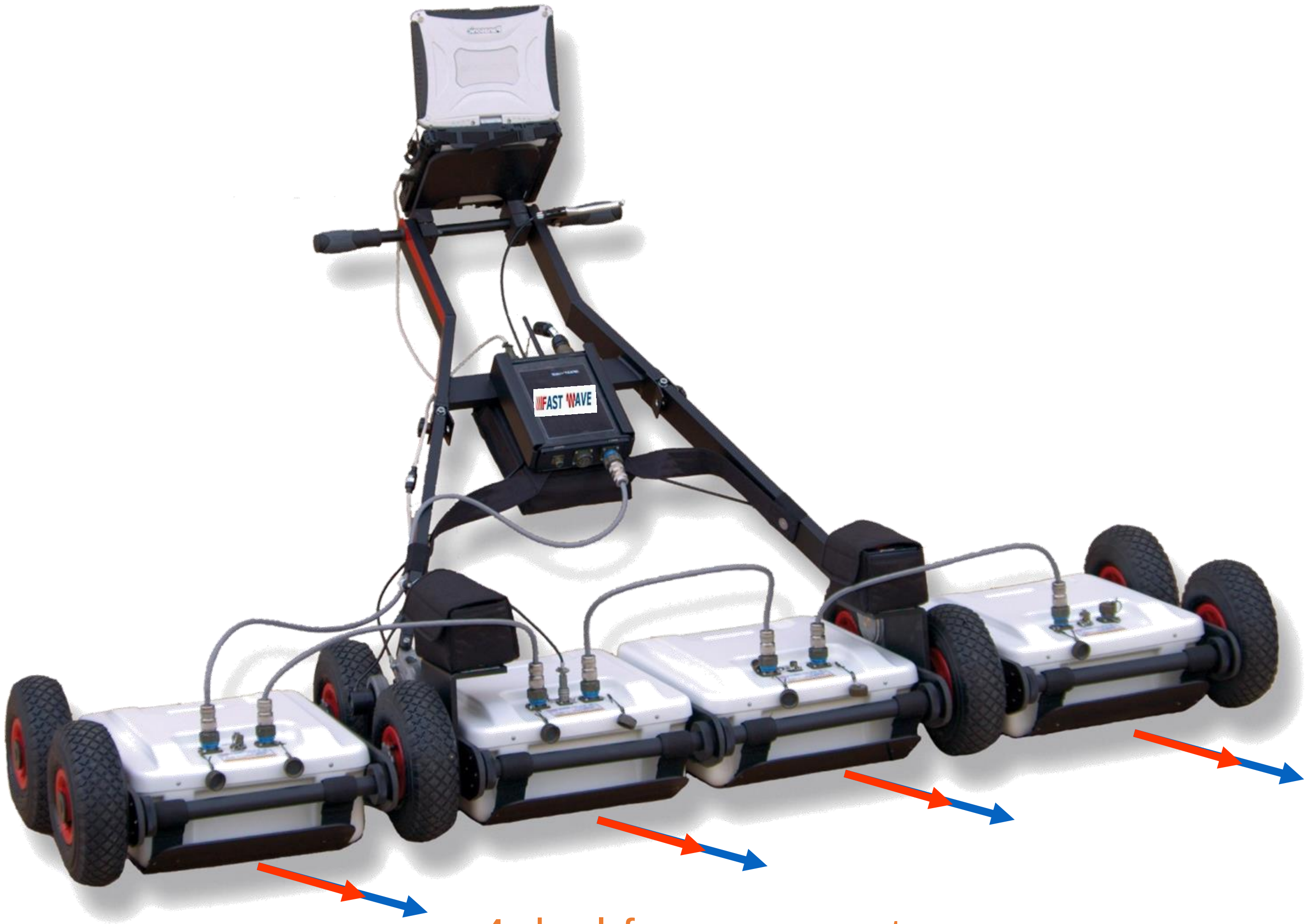


B-Scan



C-Scan (Tomography)

SOLUTION: Multi-antenna systems: RIS MF Hi-MOD



4 dual-frequency antennas
(200-600 MHz)

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SOLUTION: Closely-spaced antenna array systems

STREAM EM

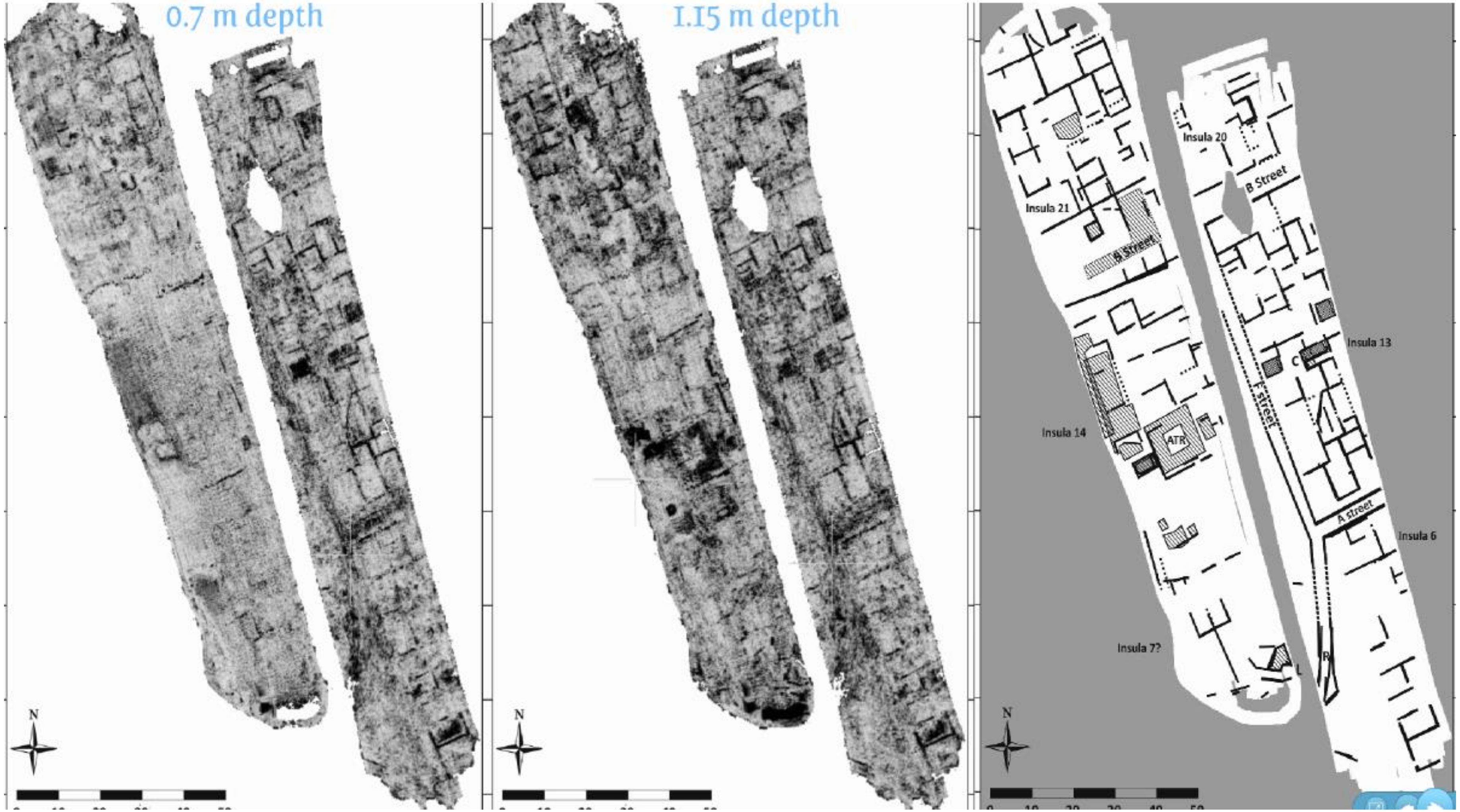
RIS Hi-BrigHT

STREAM X

And...customized systems

RESULTS

Empuries, Spain (Novo et al. 2011)



RESULTS

Charleston, SC (2011)

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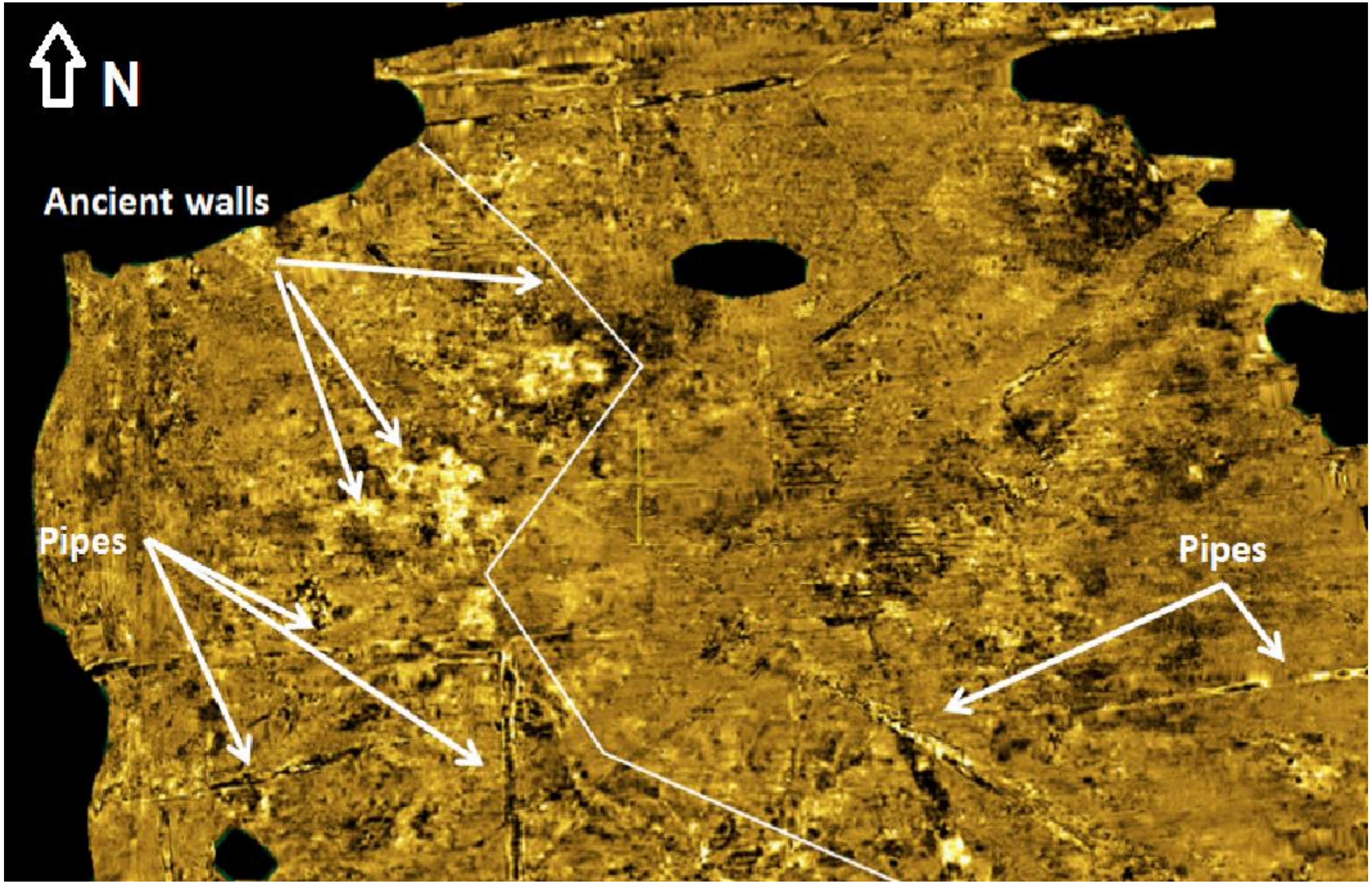


PART OF HEXAGON

WHY MCGPR? BECAUSE WE CAN DO MAPPING

WHY MAPPING?

News

Sinkhole traps car, killing two people

Heavy rains, garbage blamed for drainage problem on new Cuernavaca Paso Express

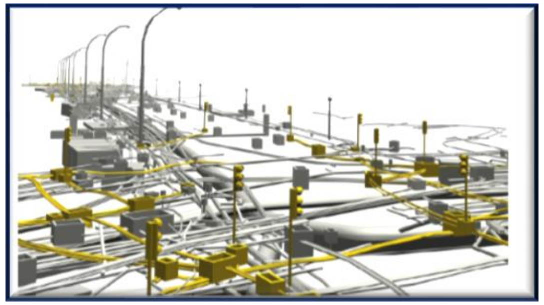
Share 304

The sinkhole that appeared this morning.

Mexico News Daily | Wednesday, July 12, 2017

Intense rainfall over the past three days has been blamed for a sinkhole that trapped a car this morning on the new Cuernavaca Paso Express, killing both occupants.

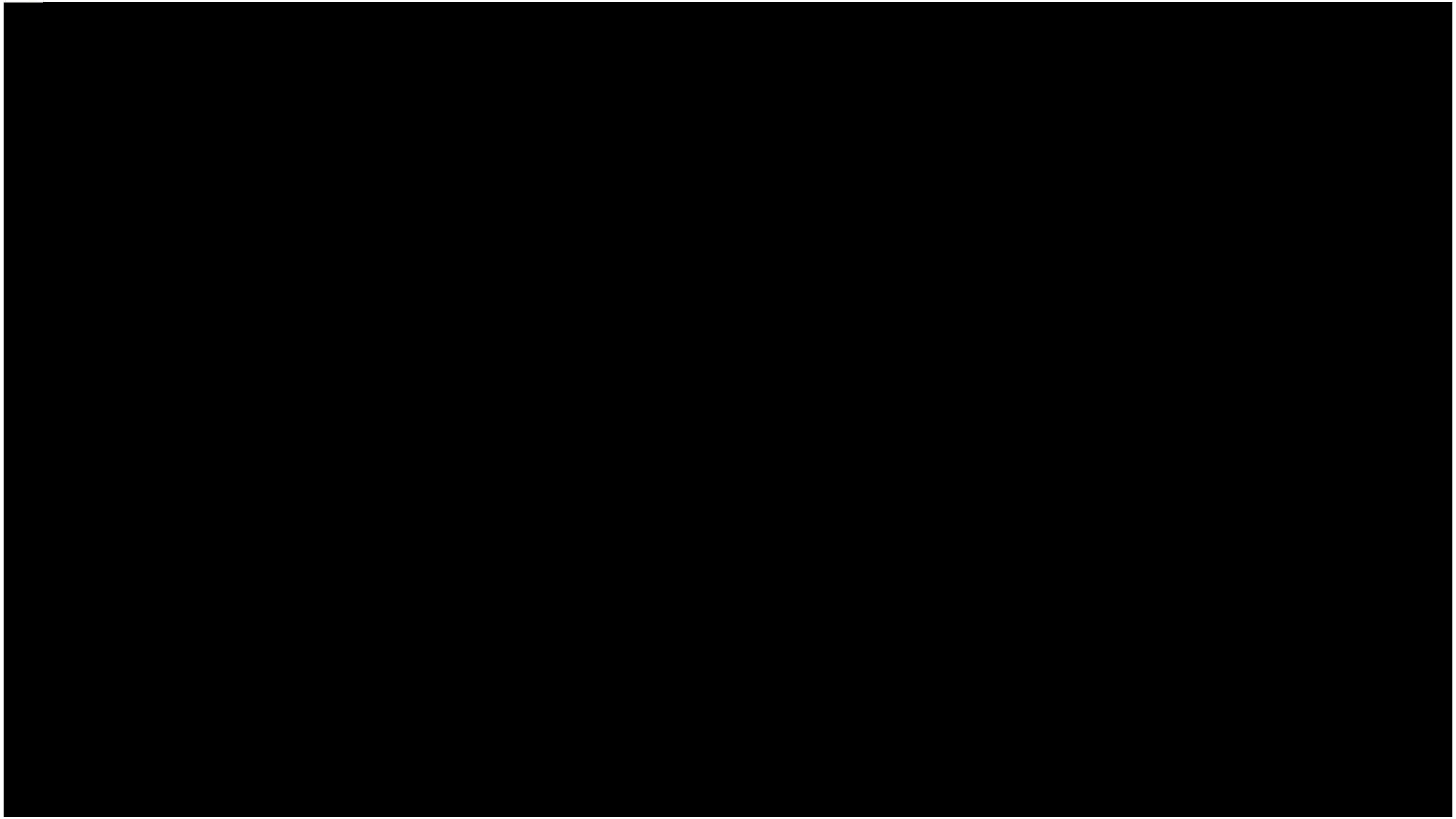
MULTICHANNEL GPR SYSTEMS FOR UTILITY DETECTION AND MAPPING



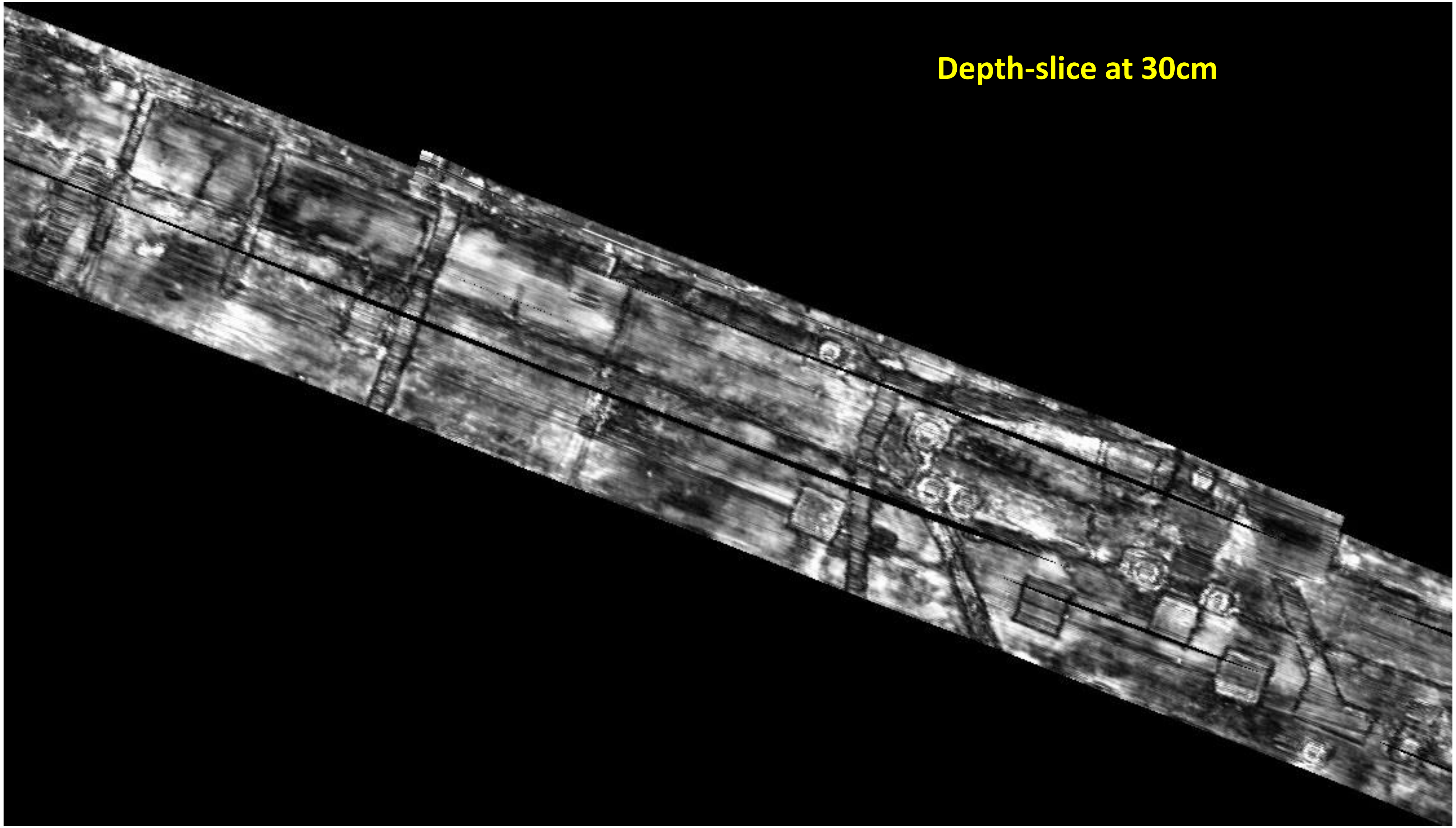
UTILITY DETECTION AND MAPPING

Real-time detection and mapping	OPERA DUO
Modular array for Detection and mapping	RIS MF Hi-Mod
Compact array for Real-time, automatic pipe detection and mapping	STREAM C
Massive array for Extensive mapping	STREAM EM

STREAM EM



STREAM EM



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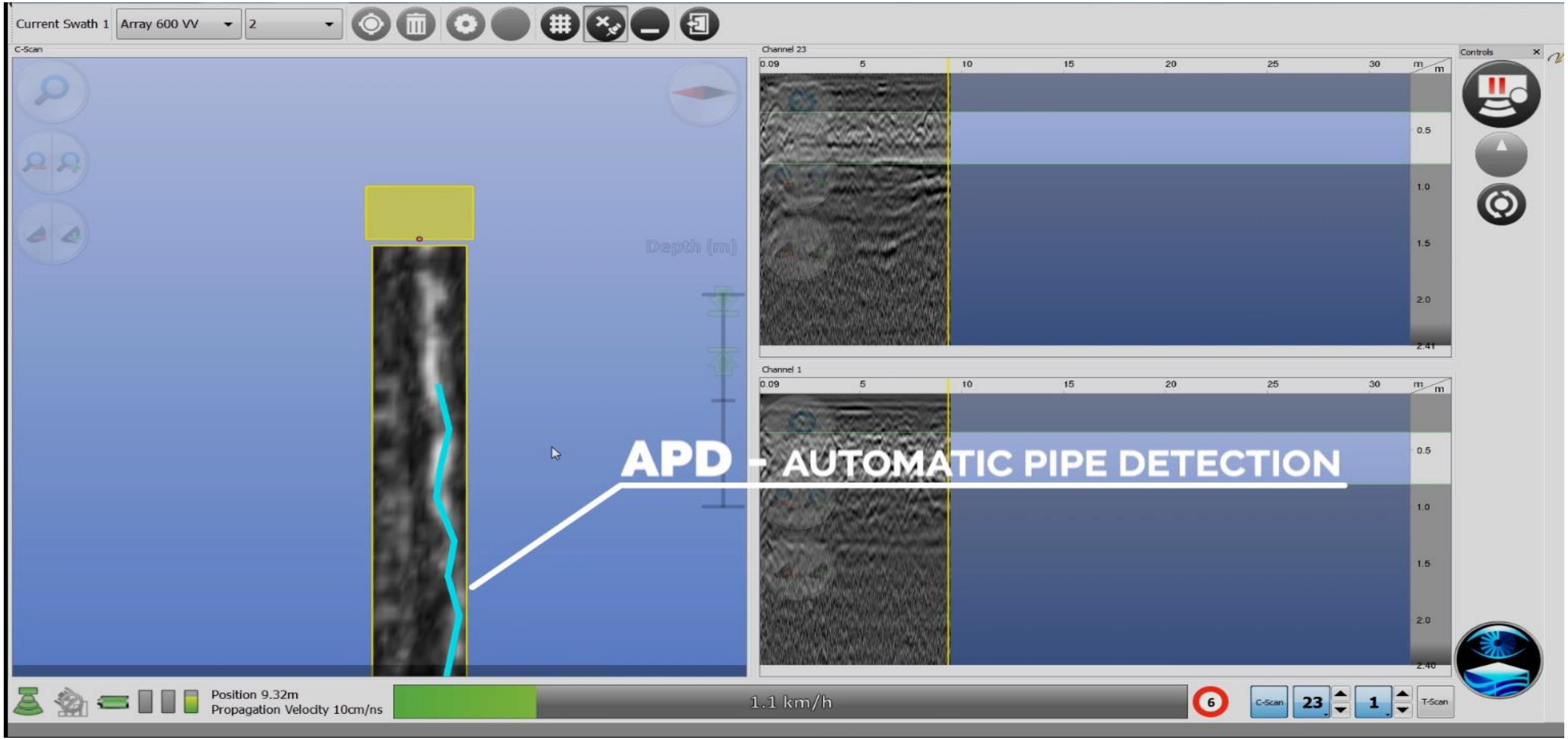
PART OF HEXAGON

STREAM C

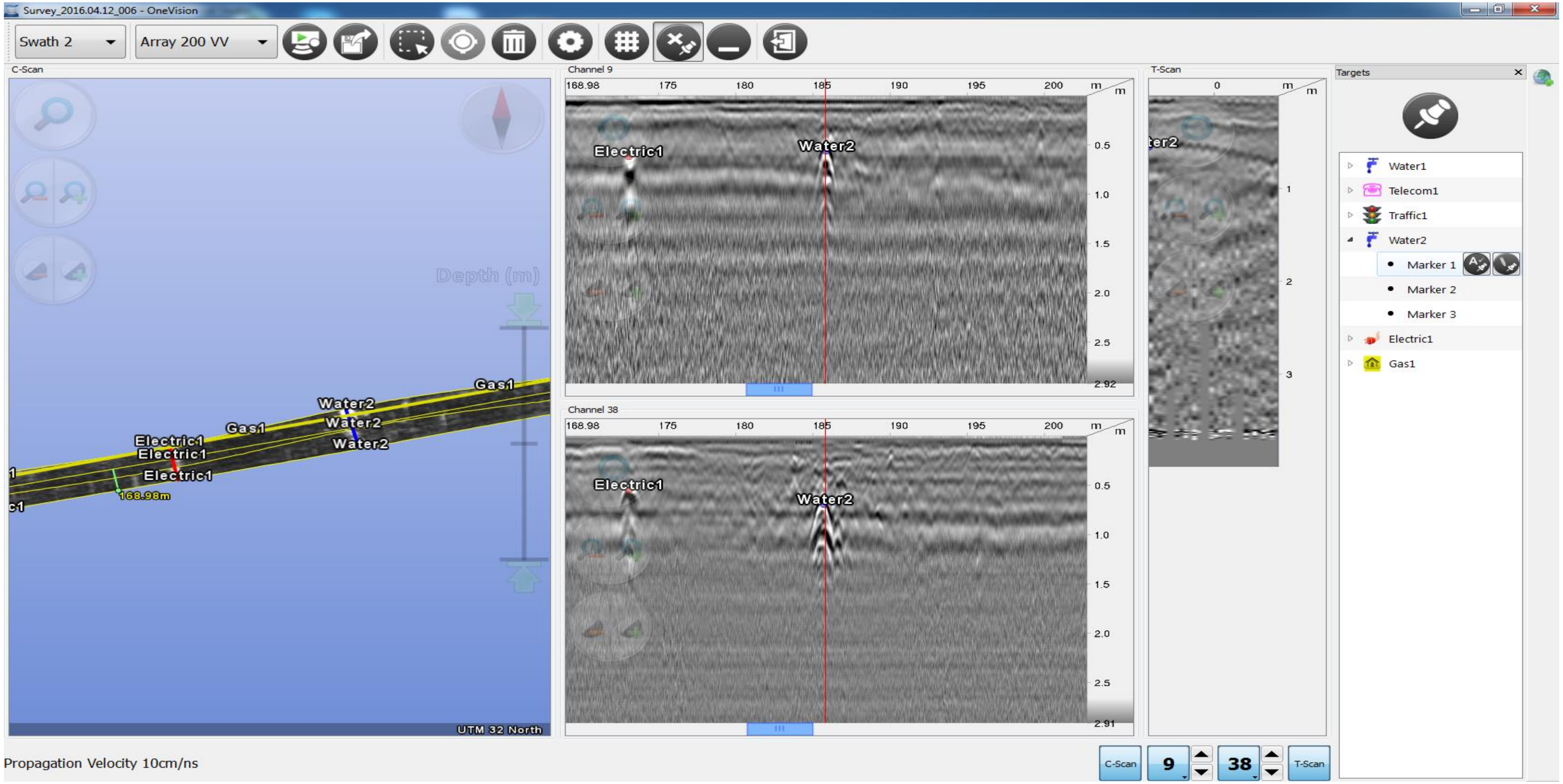
Real Time Automatic Pipe Detection



PART OF HEXAGON

STREAM C

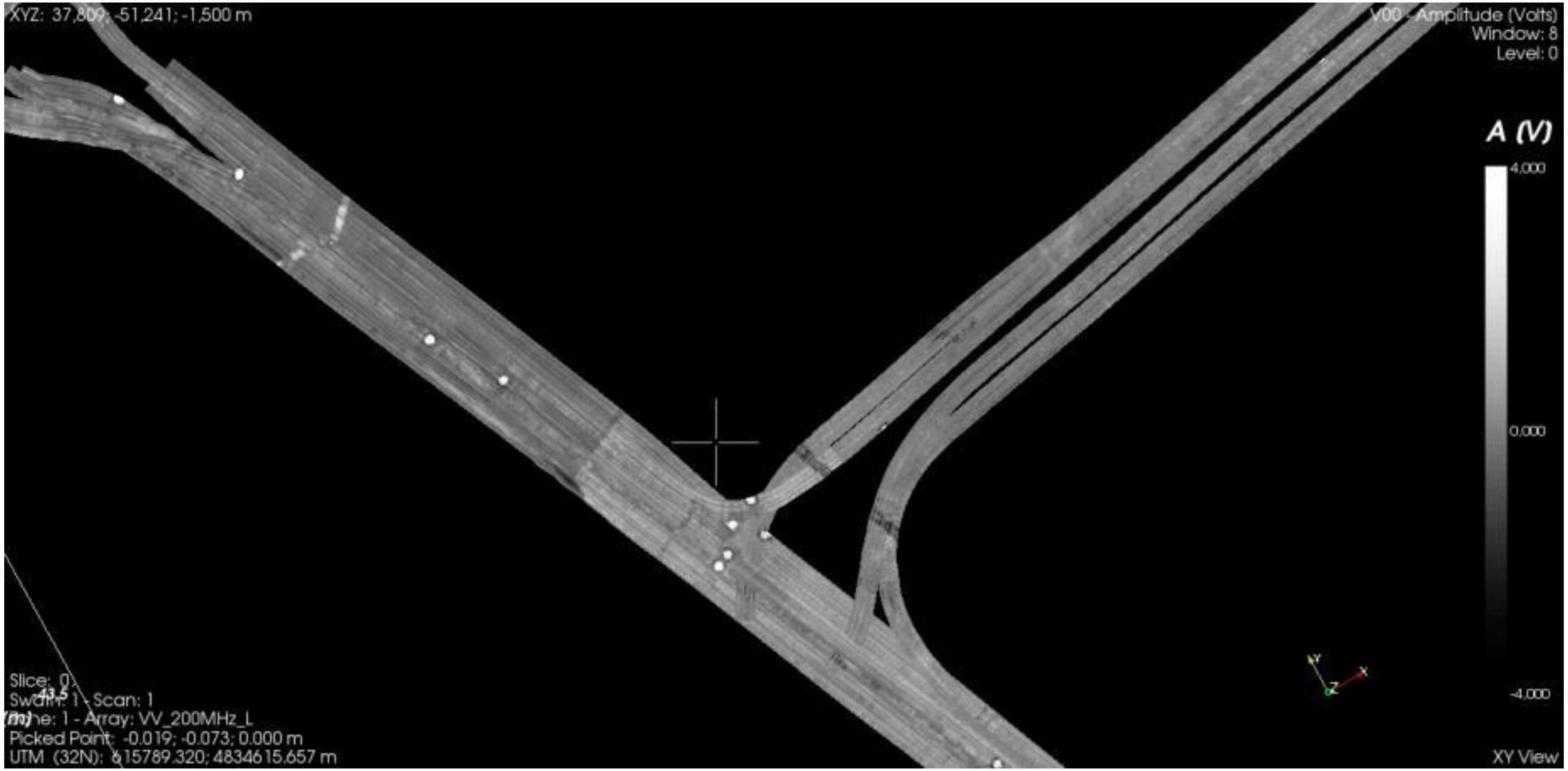
Marker Insertion



PART OF HEXAGON

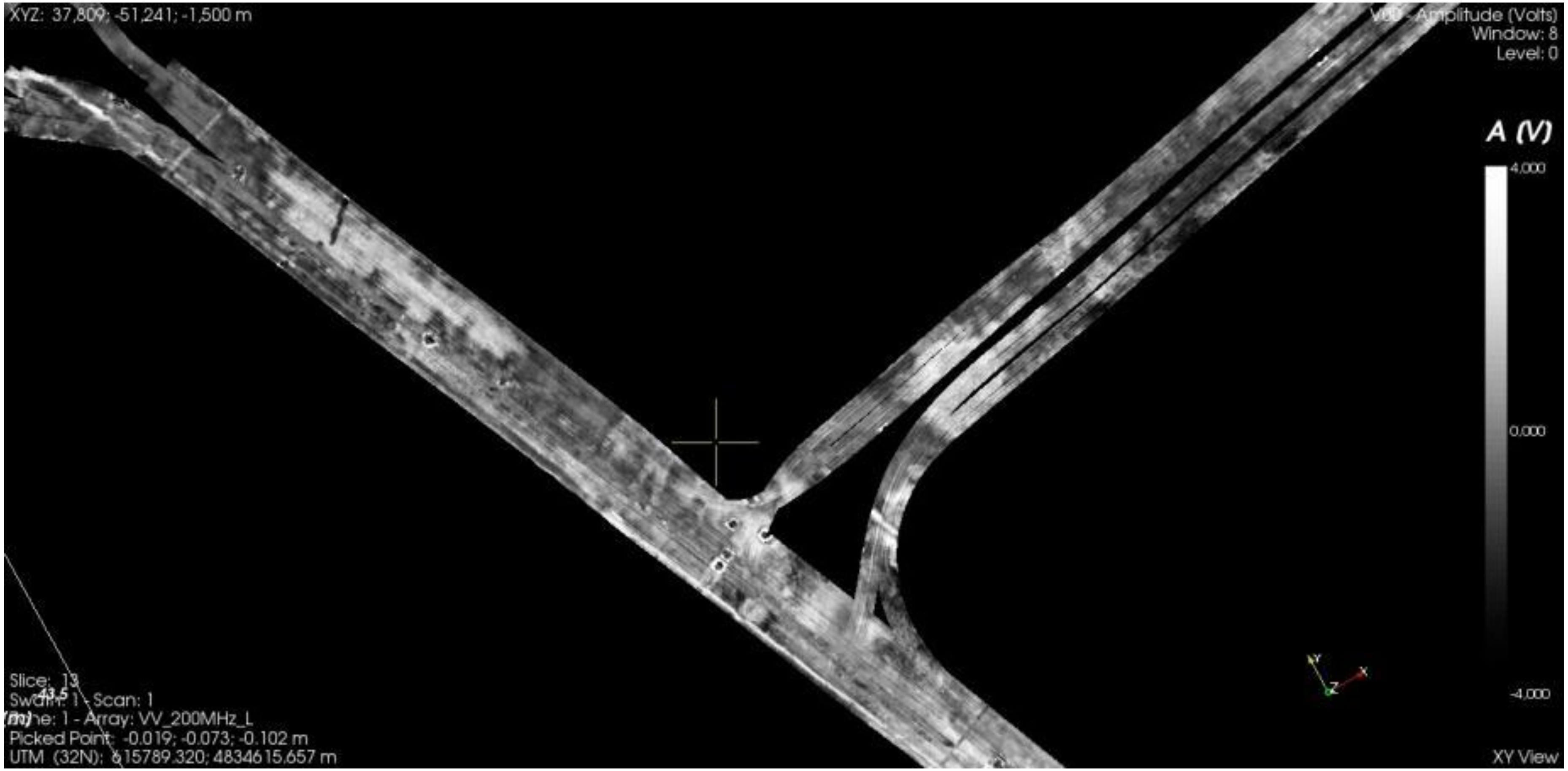
IDS GeoRadar NORTH AMERICA

STREAM EM tomography output. Depth: 0m



PART OF HEXAGON

STREAM EM tomography output. Depth: 0.1m



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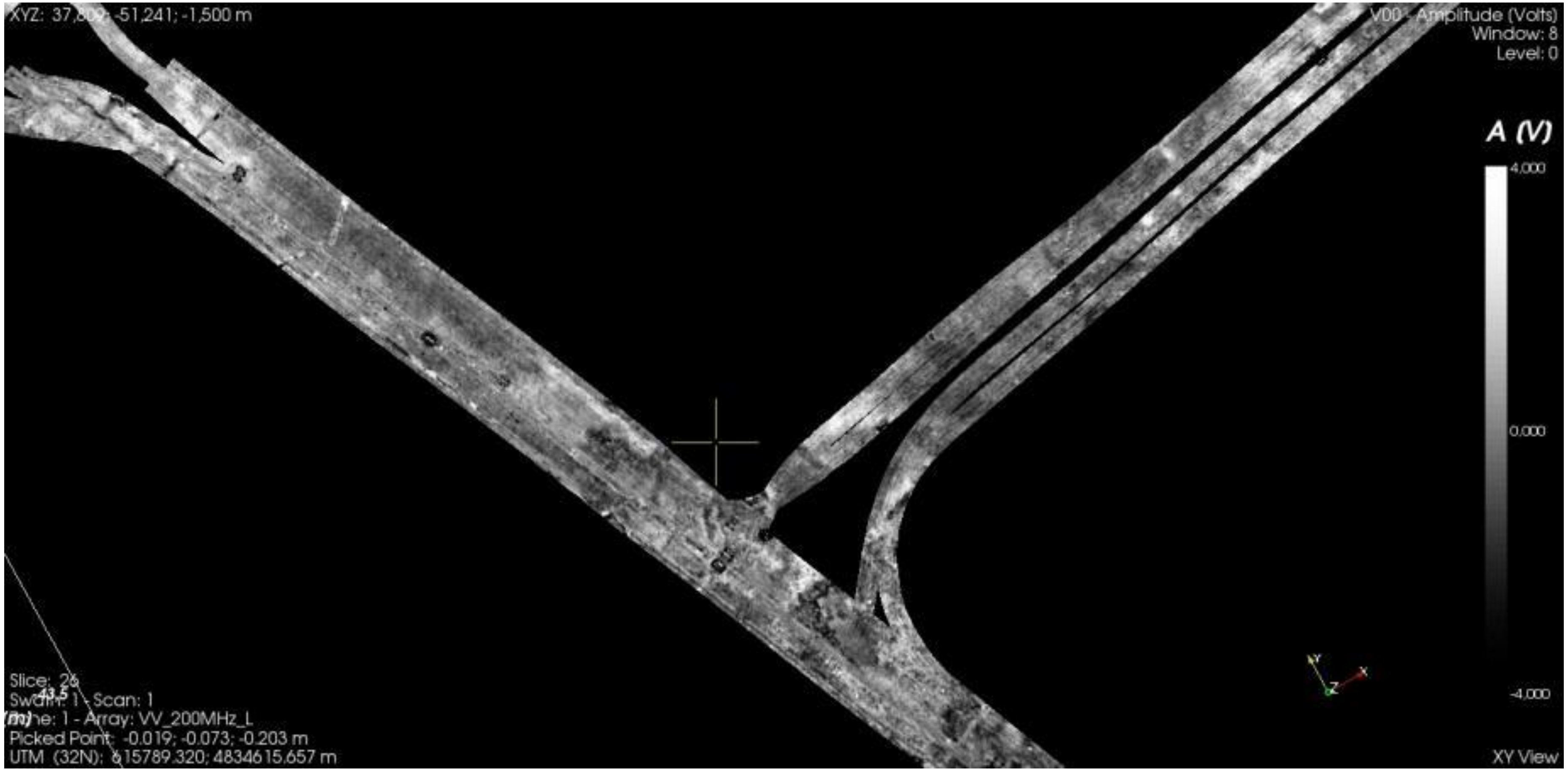
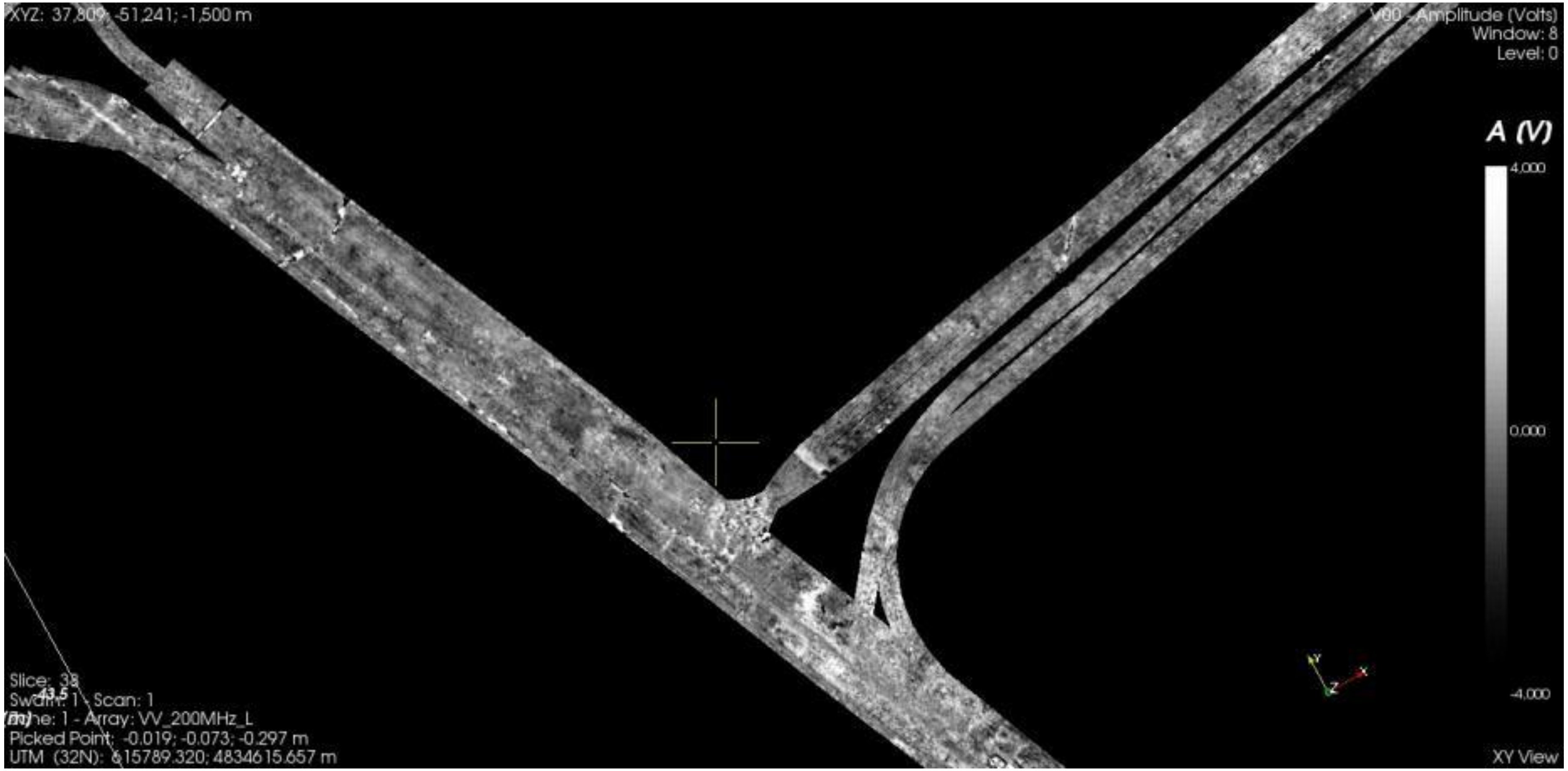
STREAM EM tomography output. Depth: 0.2m

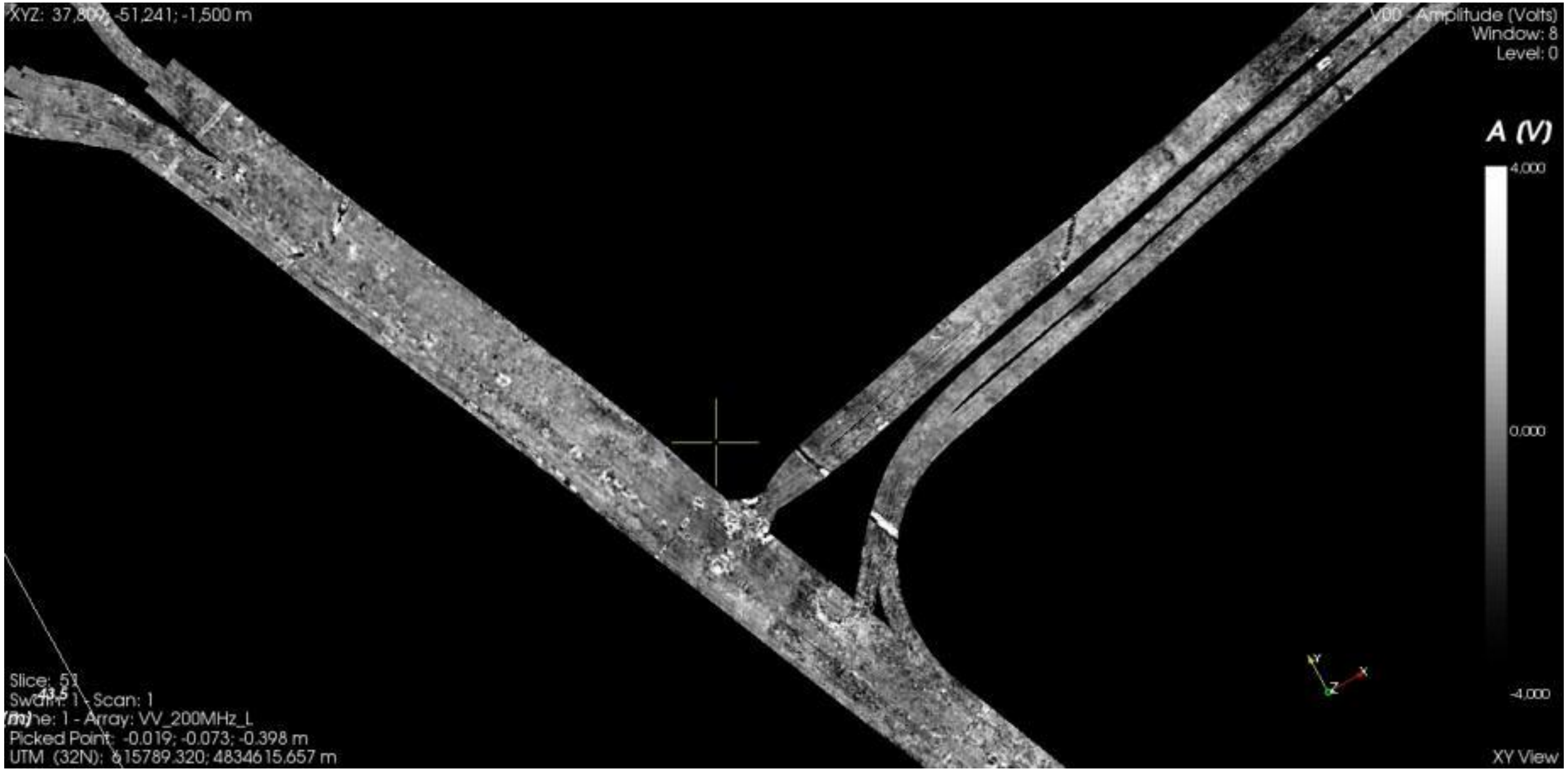


PART OF HEXAGON

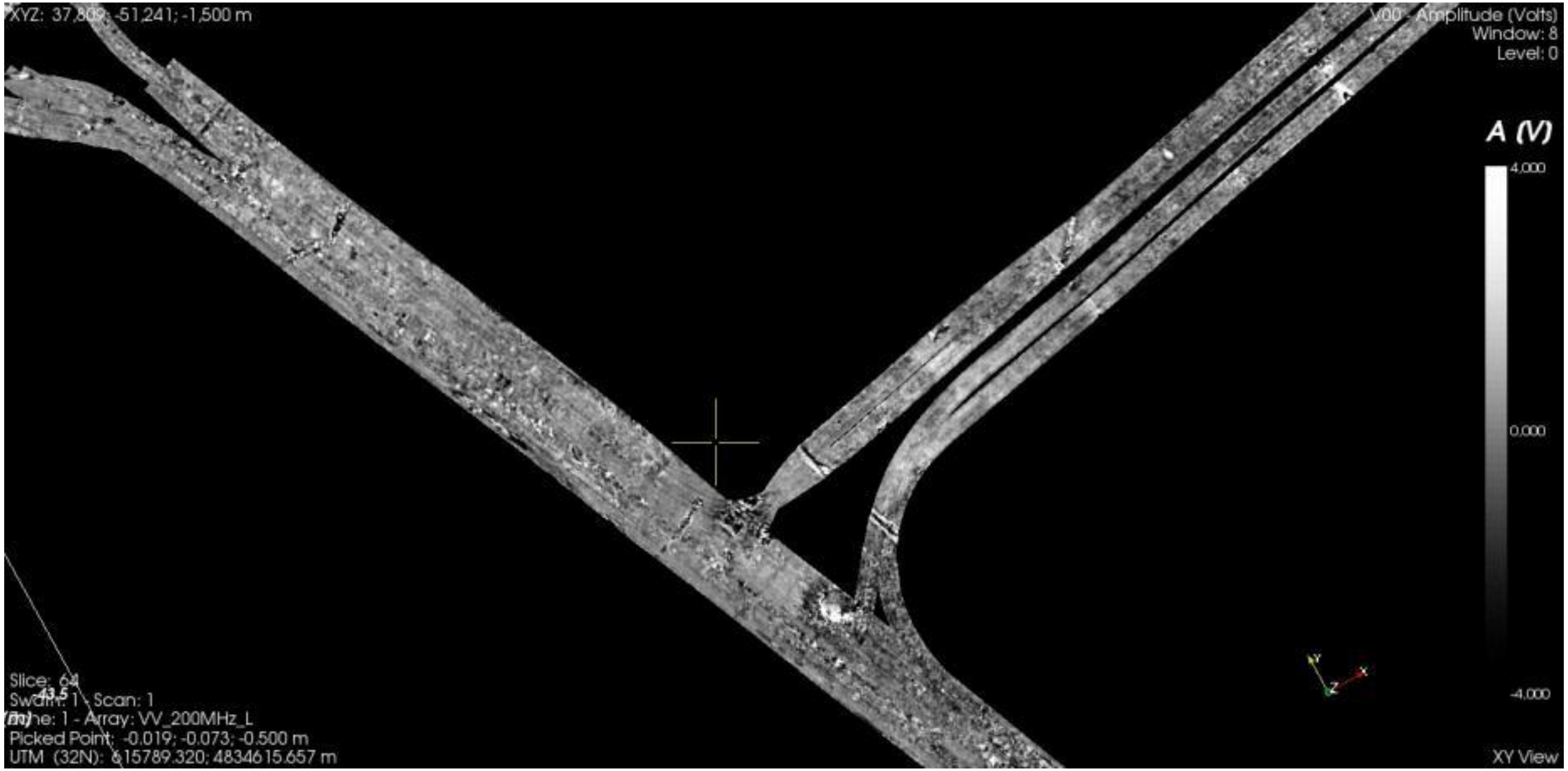
STREAM EM tomography output. Depth: 0.3m



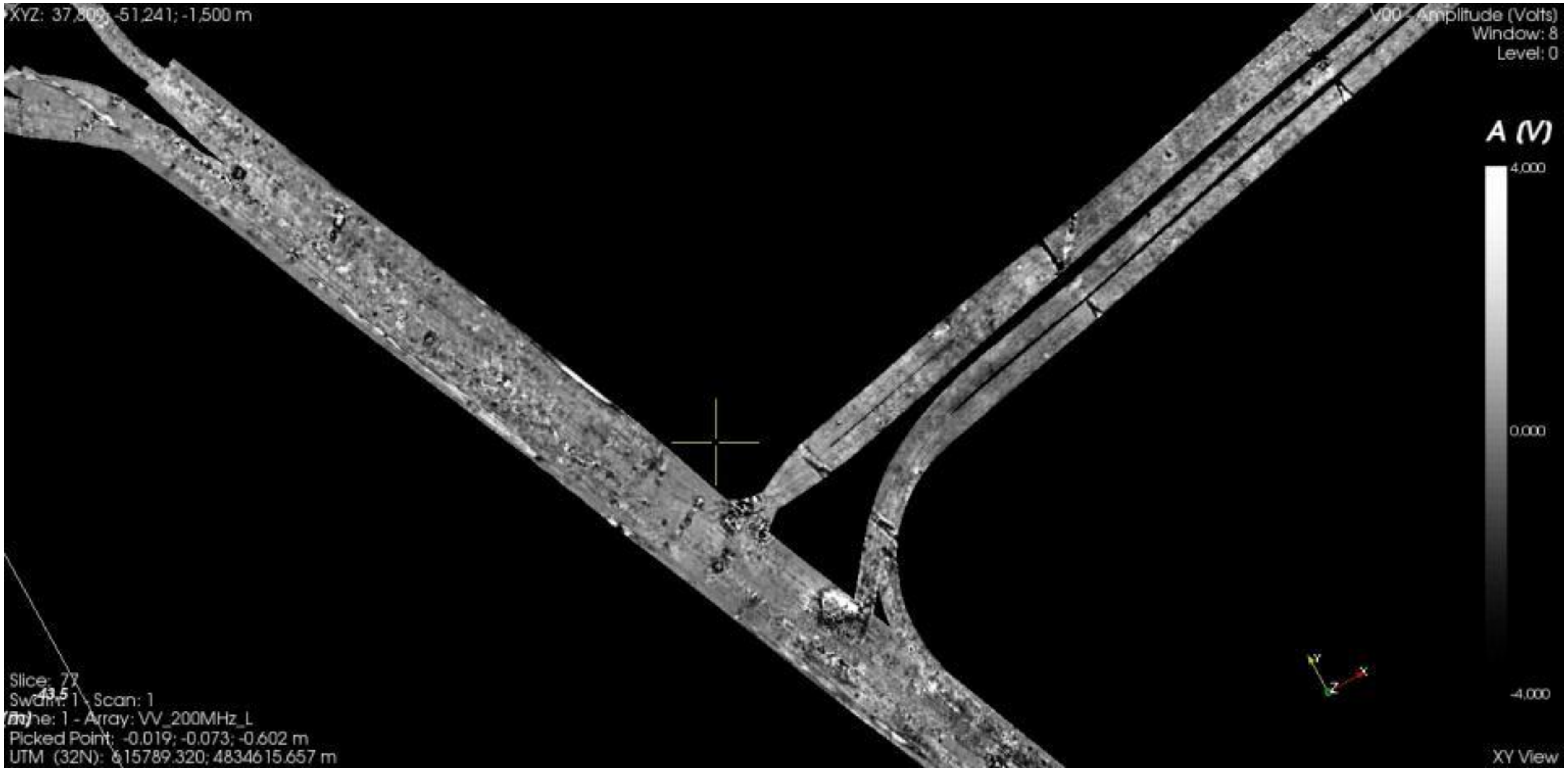
STREAM EM tomography output. Depth: 0.4m



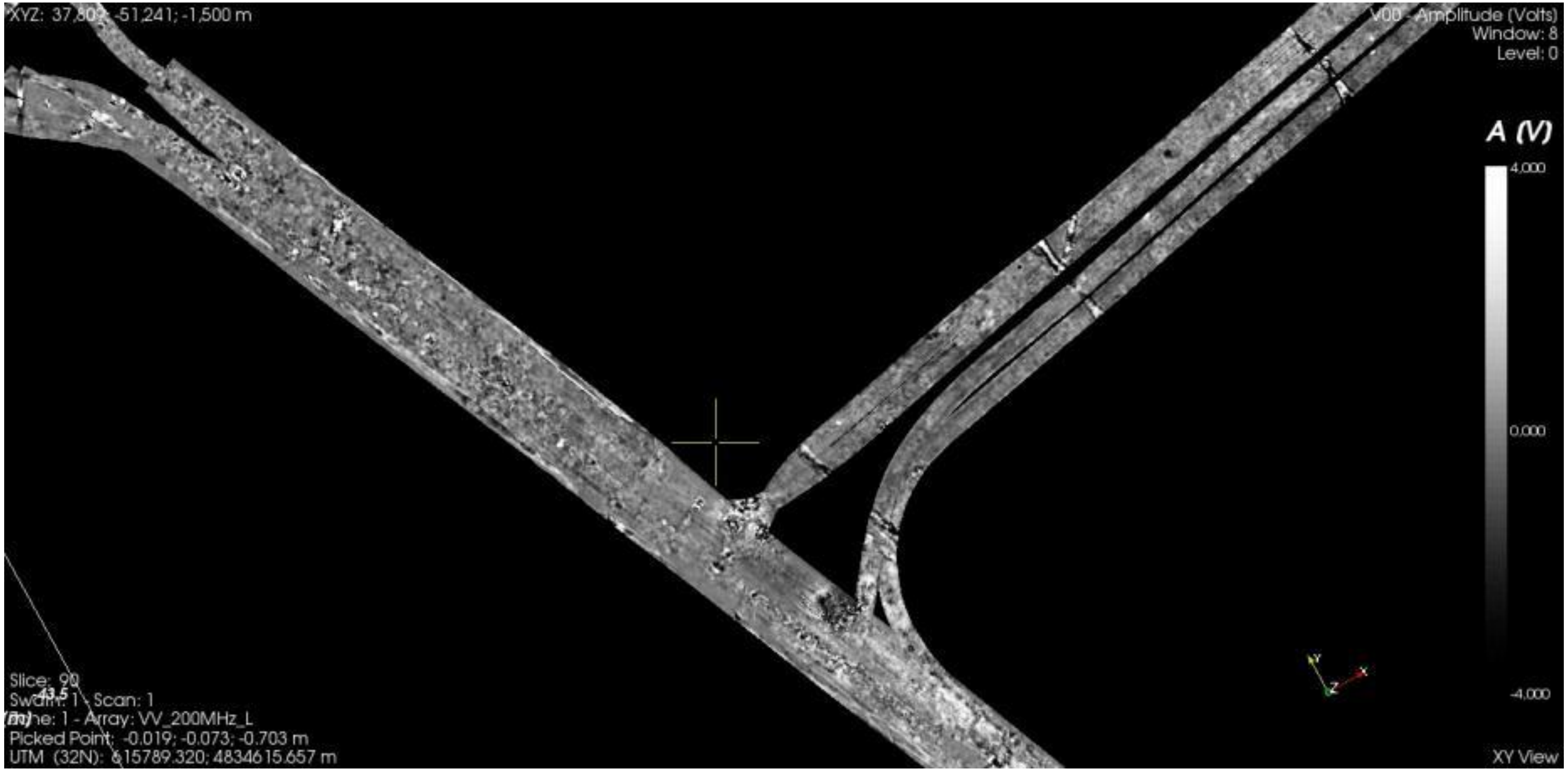
STREAM EM tomography output. Depth: 0.5m



STREAM EM tomography output. Depth: 0.6m

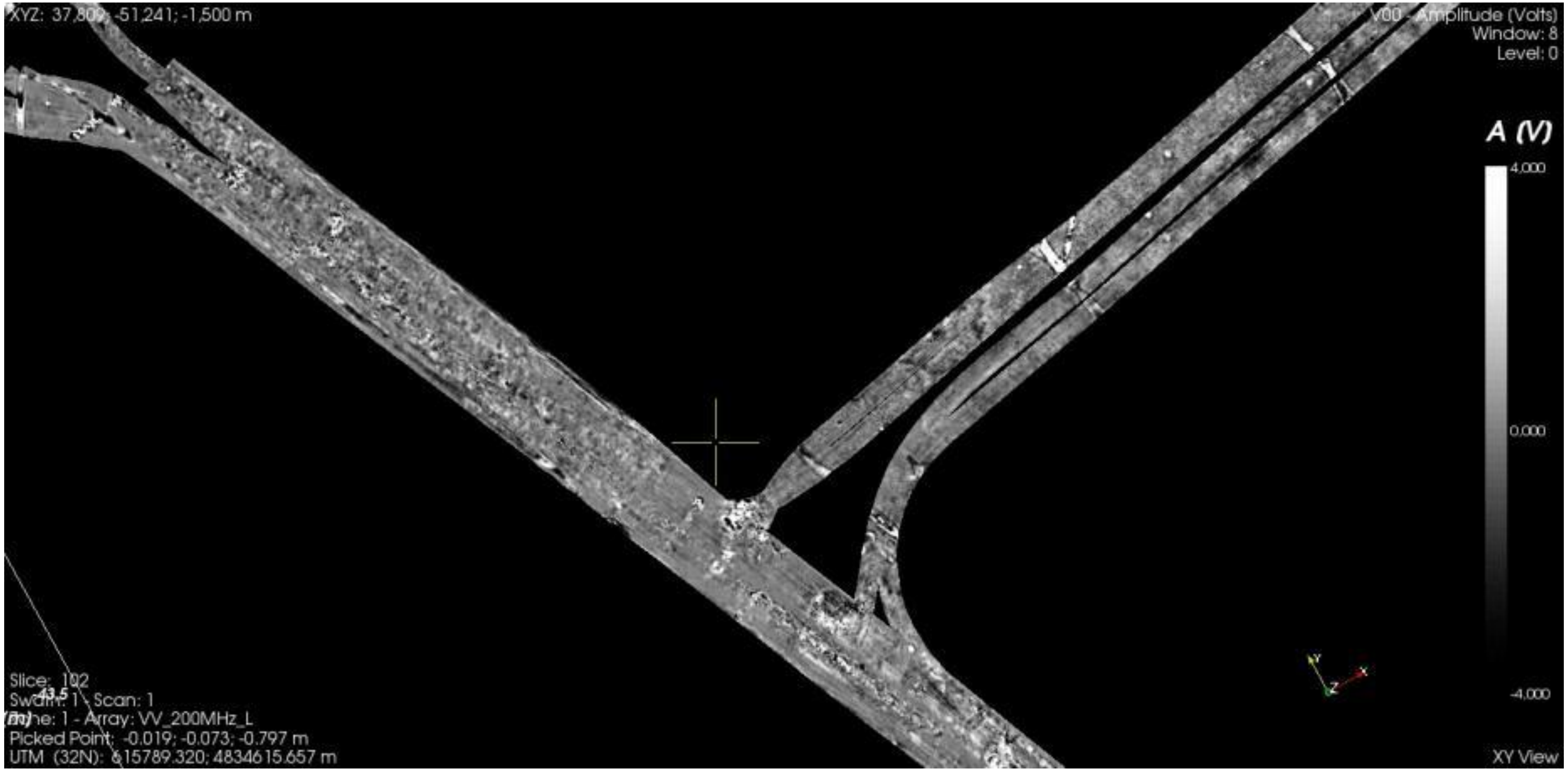


STREAM EM tomography output. Depth: 0.7m



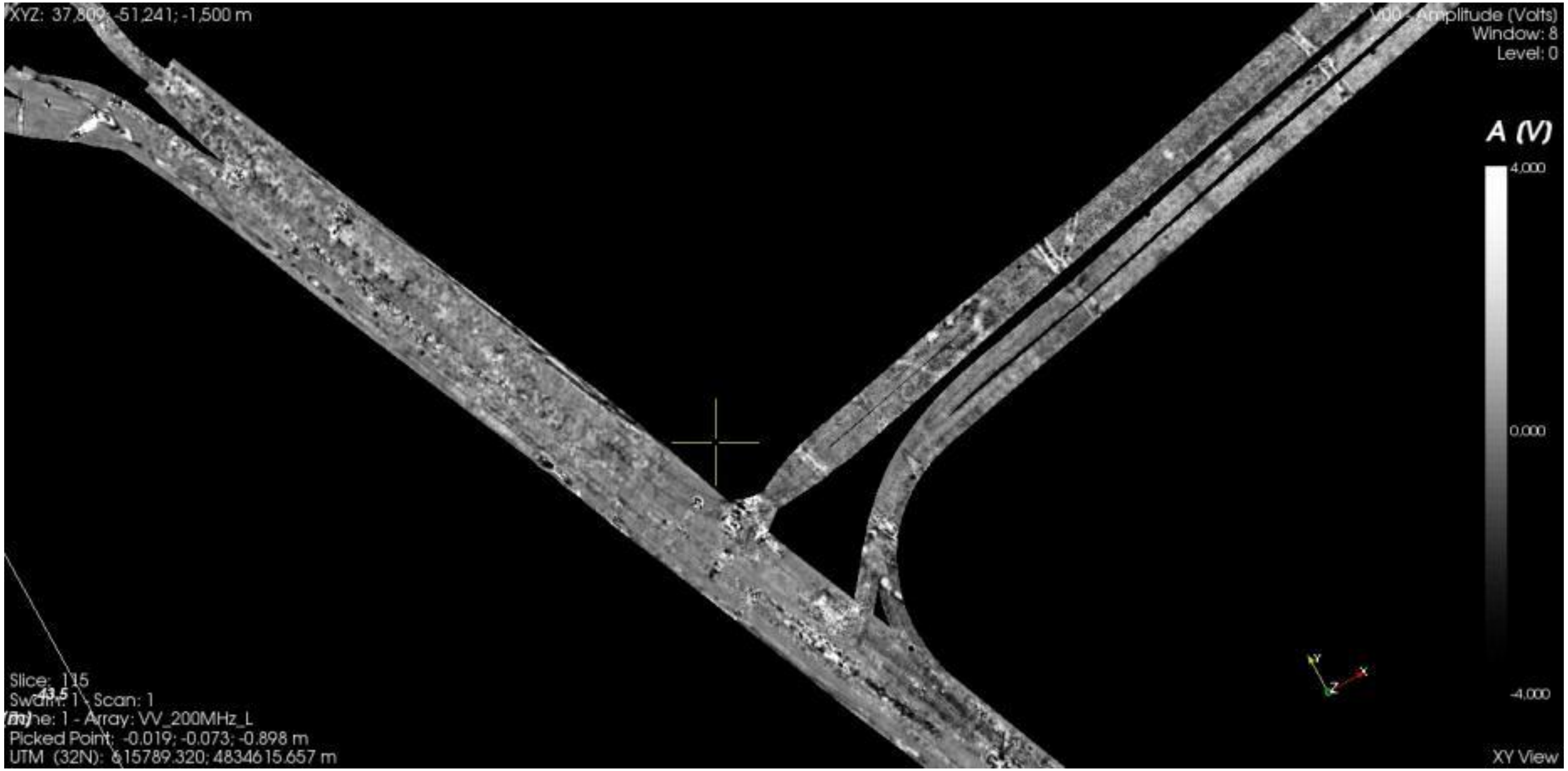
IDS GeoRadar
NORTH AMERICA

STREAM EM tomography output. Depth: 0.8m



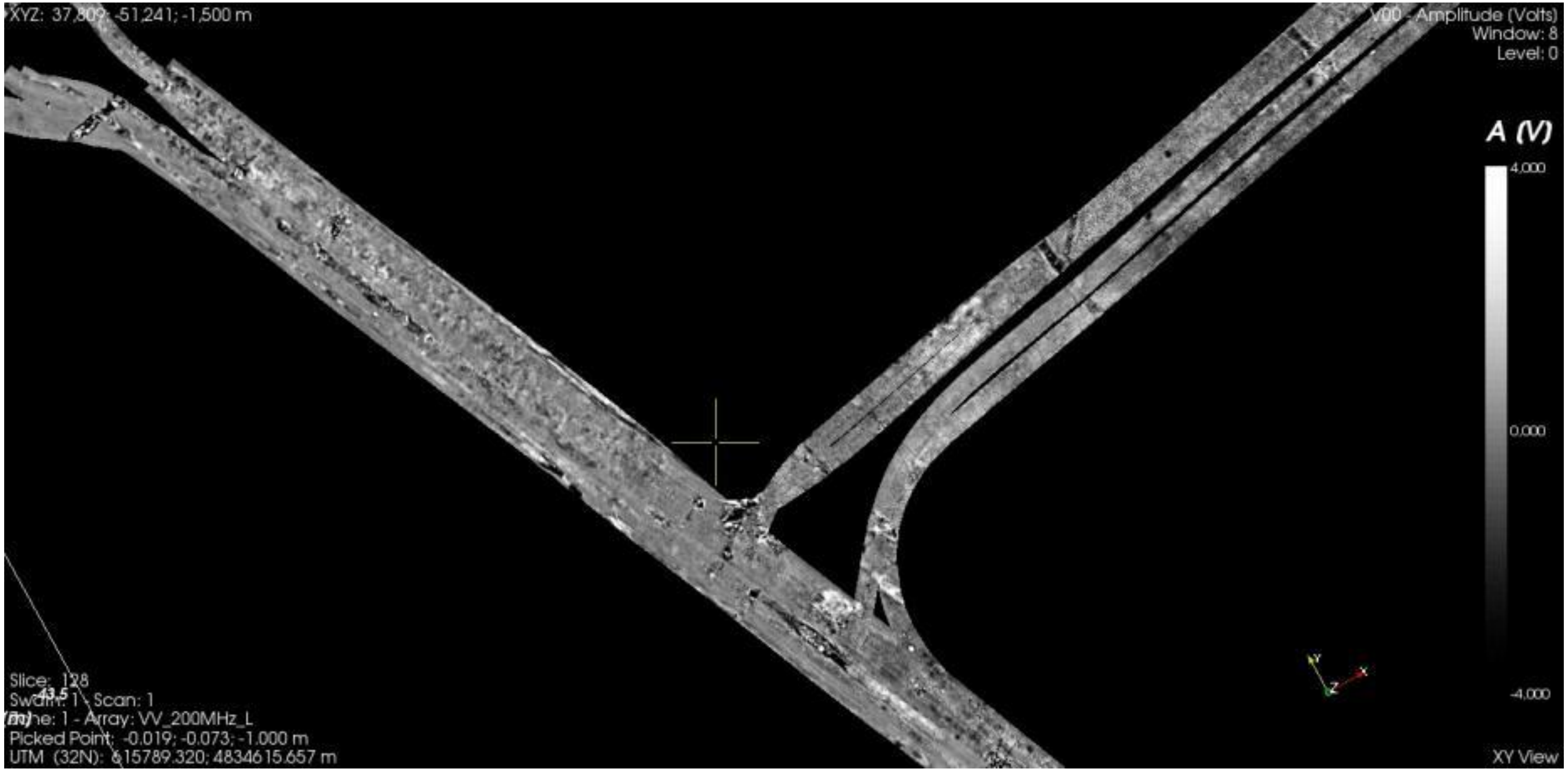
PART OF HEXAGON

STREAM EM tomography output. Depth: 0.9m



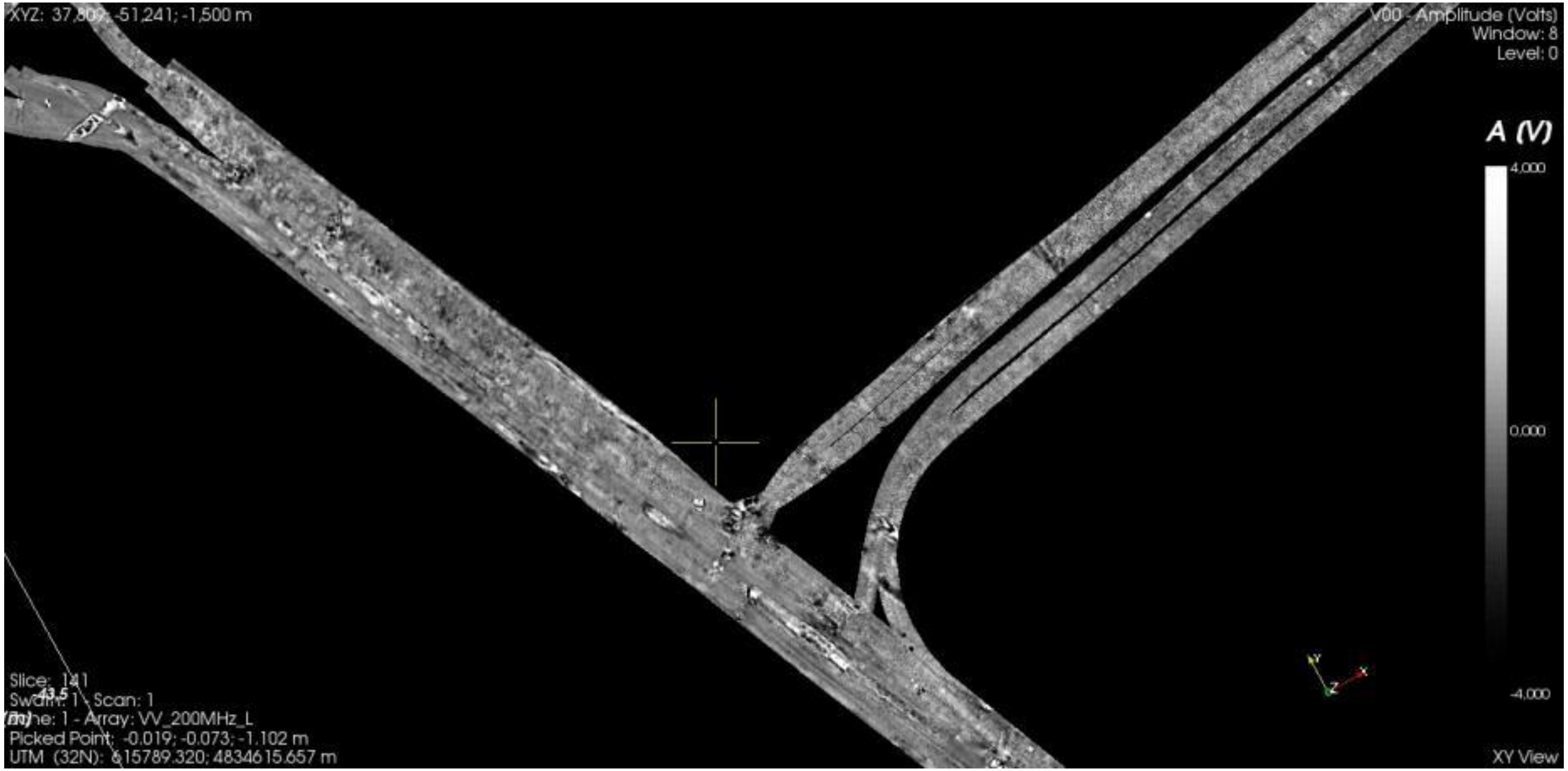
IDS GeoRadar NORTH AMERICA

STREAM EM tomography output. Depth: 1m

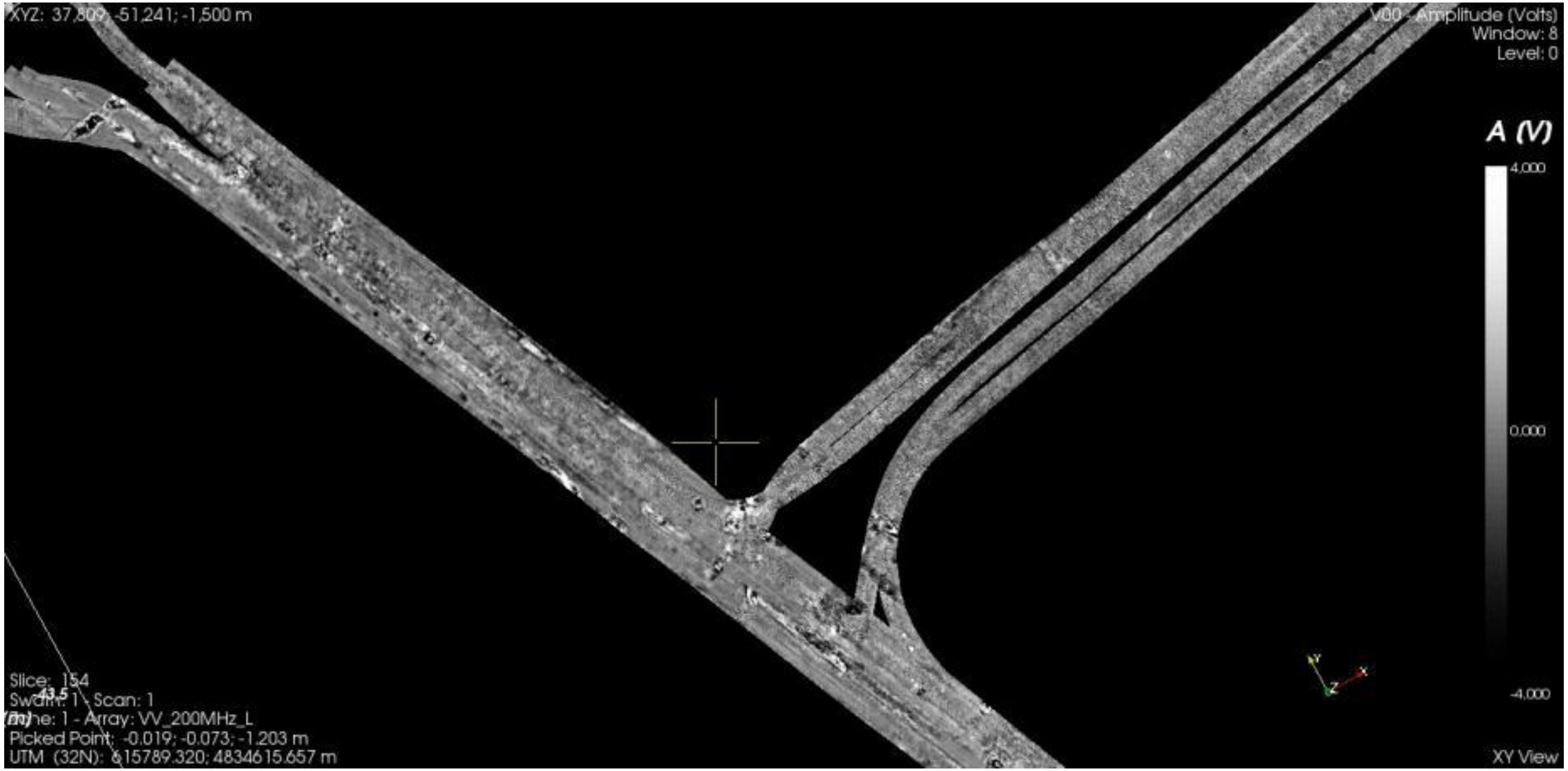


PART OF HEXAGON

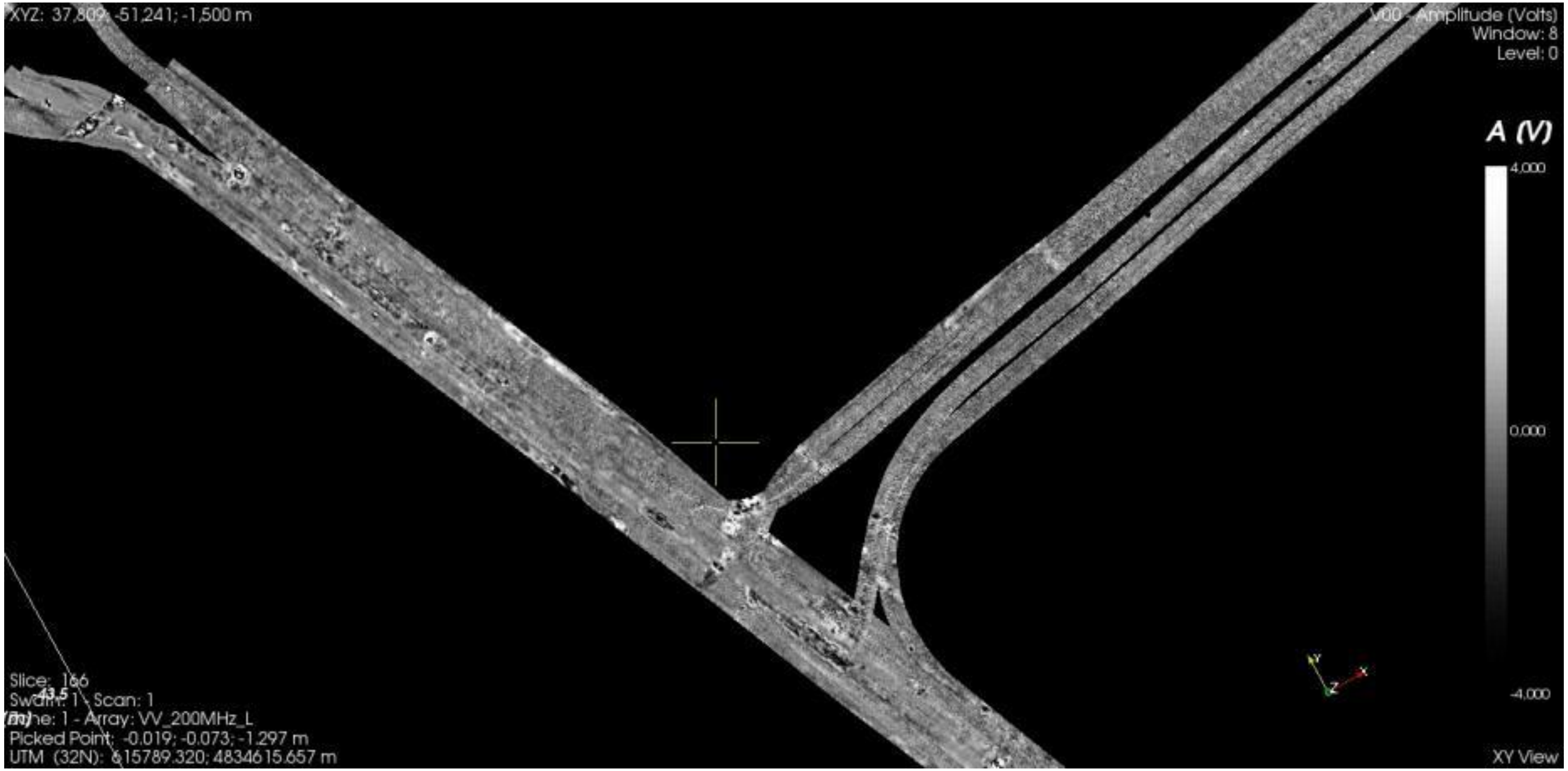
STREAM EM tomography output. Depth: 1.1m



STREAM EM tomography output. Depth: 1.2m

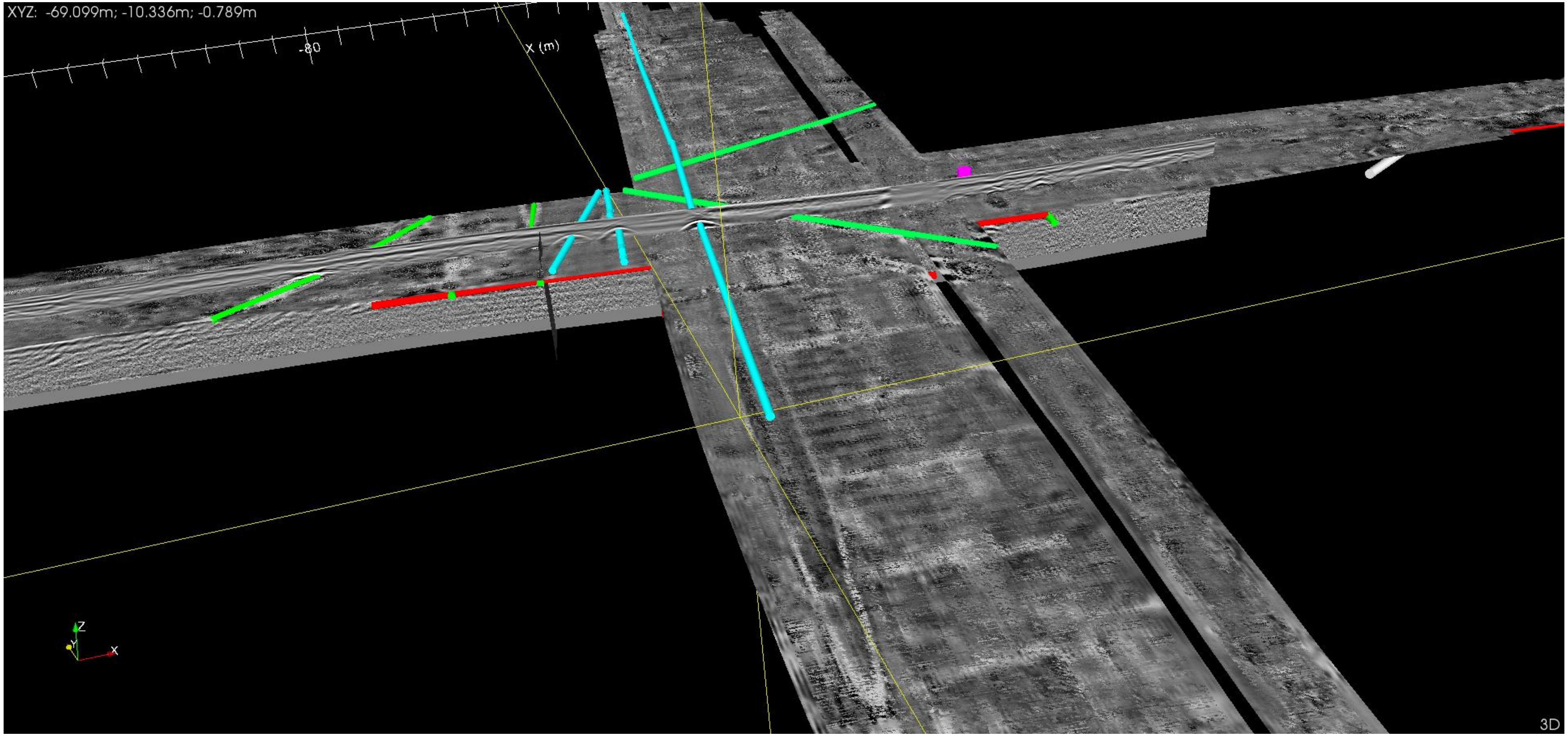


STREAM EM tomography output. Depth: 1.3m



GRED HD 3D CAD processing software

Export of Target



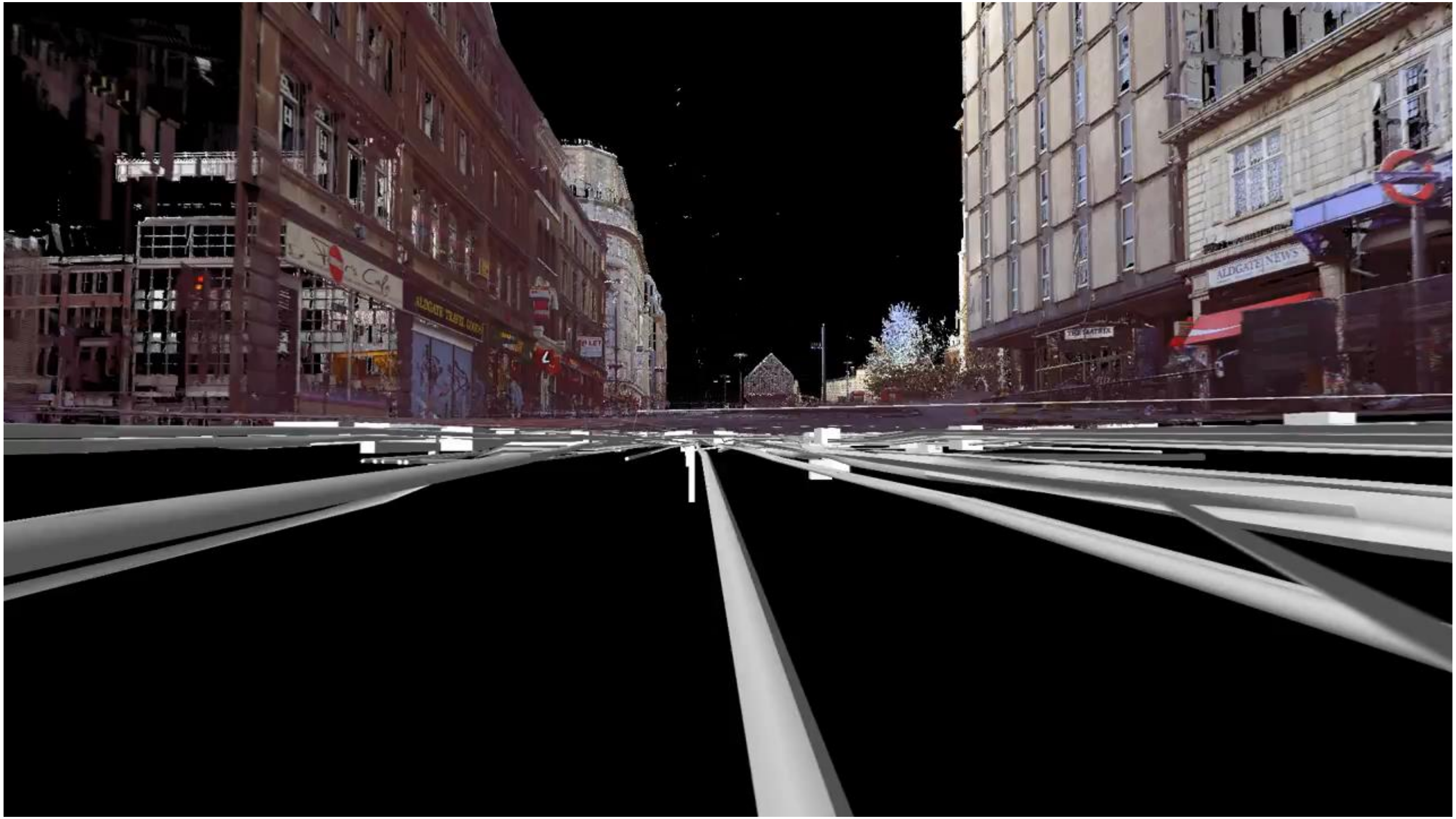
IDS GeoRadar NORTH AMERICA

PEGASUS:STREAM

Mobile Mapping:
Ground Penetrating Radar & Pegasus:Two
an integrated solution

PART OF HEXAGON

MOBILE MAPPING (ABOVE AND BELOW GROUND)



GRACIAS!!!

Overview IDS GeoRadar NORTH AMERICA

A travel through the most important Utility Mapping World Standards

Enrico Boi

What is a Standard ?

Dictionary

standard

standard

/ˈstandəd/

noun

1. a level of quality or attainment.
   "their restaurant offers a high standard of service"
   synonyms: quality, level, grade, degree, worth, calibre, merit, excellence
   "the standard of work is very good"
2. something used as a measure, norm, or model in comparative evaluations.
   "the wages are low by today's standards"

adjective

1. used or accepted as normal or average.
   "the standard rate of income tax"
   synonyms: normal, usual, typical, stock, common, ordinary, customary, conventional, habitual, accustomed, expected, wonted, everyday, regular, routine, day-to-day, daily, established, settled, set, fixed, traditional, quotidian, prevailing
   "the standard rate of income tax"
2. (of a tree or shrub) growing on an erect stem of full height.
   "standard trees are useful for situations where immediate height is needed"

Benefits of Standards

Standards ensure goods and services consistently perform the way they are intended. ... **Standards** give businesses and consumers confidence that the goods and services they are developing or using are safe, reliable and will do the job they were intended for.

- **GRADE 53 ORDINARY PORTLAND CEMENT:**

Fineness=**225 m2/kg**
Compressive strength after 3 days=**27 N/mm2**
Compressive strength after 7 days=**37 N/mm2**
Compressive strength after 28 days=**53 N/mm2**
Grade 53 cement has low chloride content and is moderately sulphate resisting. Volume of cement required is less due to high strength and surface area which saves the cost of construction.

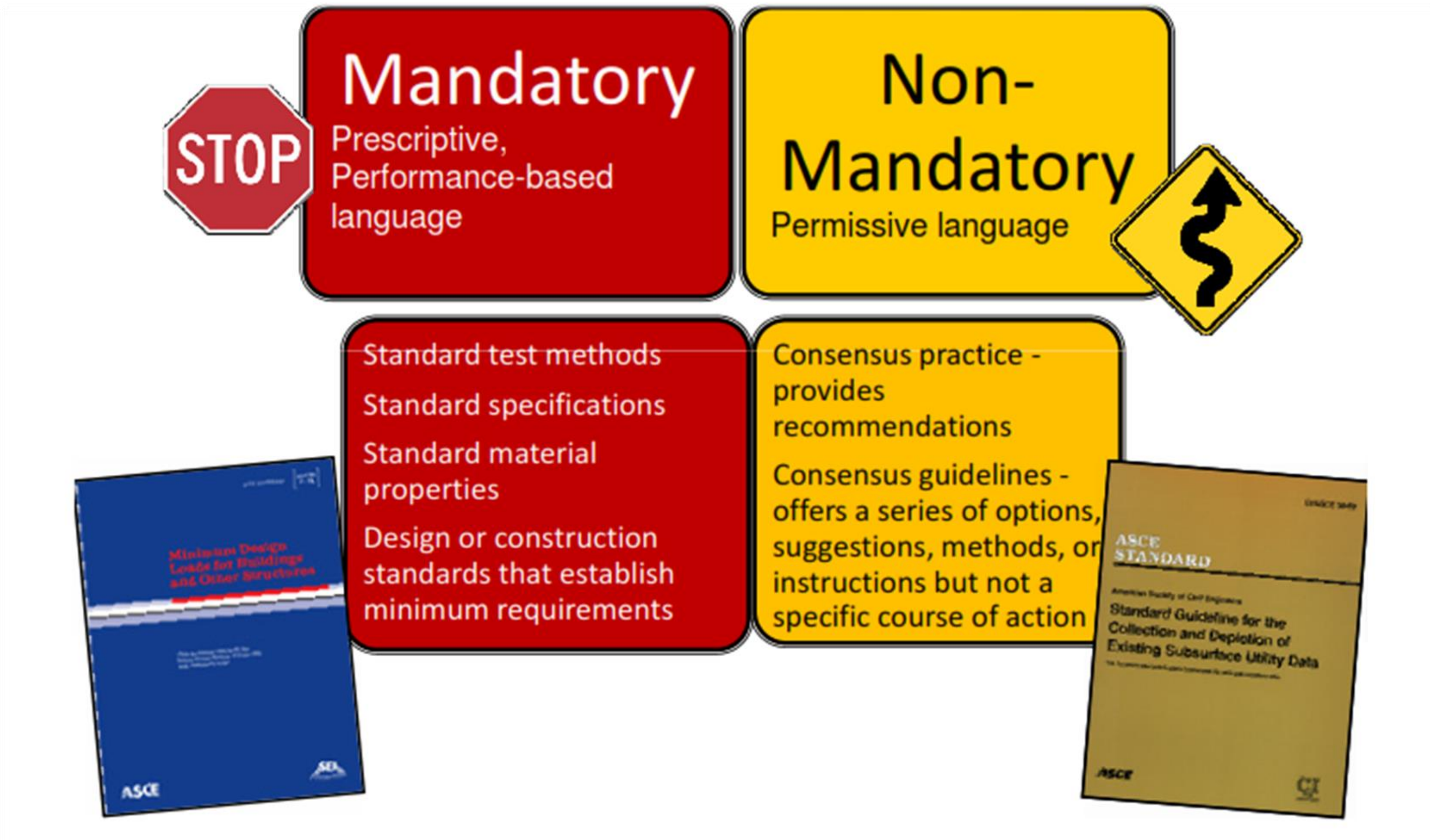
- **GRADE 33 ORDINARY PORTLAND CEMENT:**

Fineness=**300 m2/kg**
Compressive strength after 3 days=**16 N/mm2**
Compressive strength after 7 days=**22 N/mm2**
Compressive strength after 28 days=**33N/mm2**
Grade 33 cement has high workability and is mainly used for mortar in masonry work and for plastering.

- **GRADE 43 ORDINARY PORTLAND CEMENT:**

Fineness=**225 m2/kg**
Compressive strength after 3 days=**23 N/mm2**
Compressive strength after 7 days=**33 N/mm2**
Compressive strength after 28 days=**43 N/mm2**
Grade 43 cement is moderately sulphate resisting and has good workability. Grade 43 cement has low chloride content and thus resists corrosion on R.C.C. Grade 43 cement has smooth and better finish.

Different types of Standards



Why the need of Standards for utility mapping ?

Why the need of Standards for utility mapping ?

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Why the need of Standards for utility mapping ?

Why the need of Standards for utility mapping ?

Why the need of Standards for utility mapping ?

Why the need of Standards for utility mapping ?

Why the need of Standards for utility mapping ?

Some statistics !!!

Key Takeaways

This year's DIRT Report highlights several key takeaways that demonstrate that despite the increase in damages submitted to DIRT, the industry continues to make progress in several key areas:

- Estimated total U.S. damages increased 20%, from 317,000 to 379,000.
- Since 2010, damages have stabilized into the 300,000–400,000 range despite there being a rebound in construction spending.
- Damages per 1000 transmissions increased 14%, from 1.54 in 2015 to 1.76. However, the rate is lower than the 2013 and 2014 rates of 2.07 and 1.84 respectively, indicating a long-term trend of improvement.
- The ratio of damages to construction spending has declined dramatically from 0.63 damages per million dollars of construction spending in 2004 to 0.41 in 2016.
- Call before you dig awareness remains consistent with historical findings at 45% (survey taken June 2017).
- The societal costs associated with underground facility damages in the U.S. in 2016 are estimated at $1.5 billion. This is a minimum estimate based on routine costs for stakeholders directly connected to a damaged facility. It does not include costs such as property damage, evacuations, road closures, environmental impacts, lawsuits, injuries, and fatalities.

IS IT CONVENIENT TO USE MAPPING STANDARDS ?

In Numbers……

Penn State University Study for PENNDOT - 2007

(Department of Transportation Pennsylvania State)

Costs analysis applied on 10 randomly selected projects related to transport infrastructures.

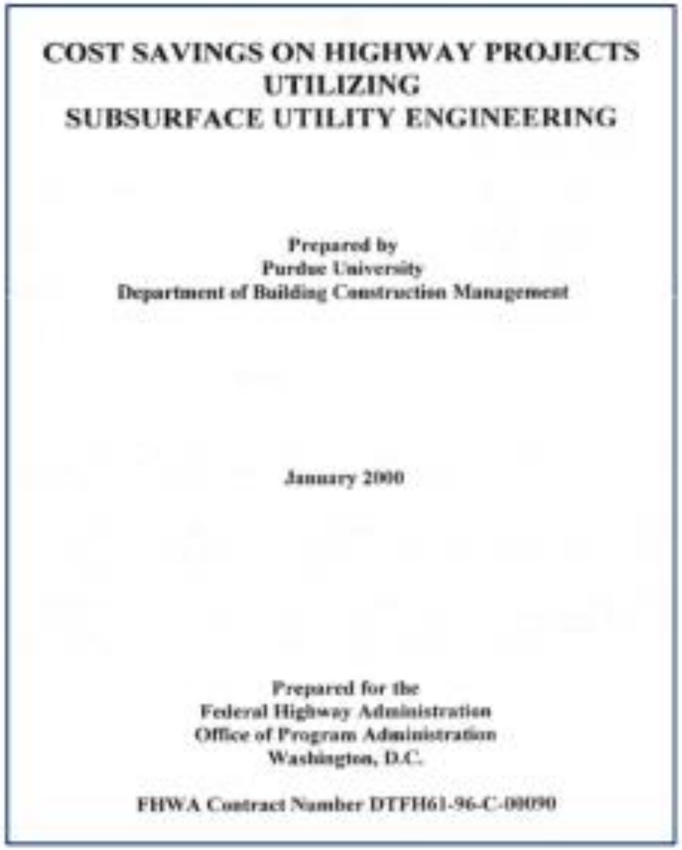
Looked at:

- Utility relocation costs;
- Utility damage costs;
- Emergency restoration costs;
- Traffic delay costs;
- Business impact costs;
- User service costs;
- Environmental impact costs;
- Information gathering costs (i.e. not using instrument Mapping;
- Legal & Litigation Costs;
- Efficient design costs.

Savings of $22.21 for every $1 spent in upgrading to high standards mapping as opposed to projects using low standards mapping.

Total cost of obtaining high standard mapping was 0.6 % of project cost.

In Numbers……


COST SAVINGS ON HIGHWAY PROJECTS
UTILIZING
SUBSURFACE UTILITY ENGINEERING

Prepared by
Purdue University
Department of Building Construction Management

January 2000

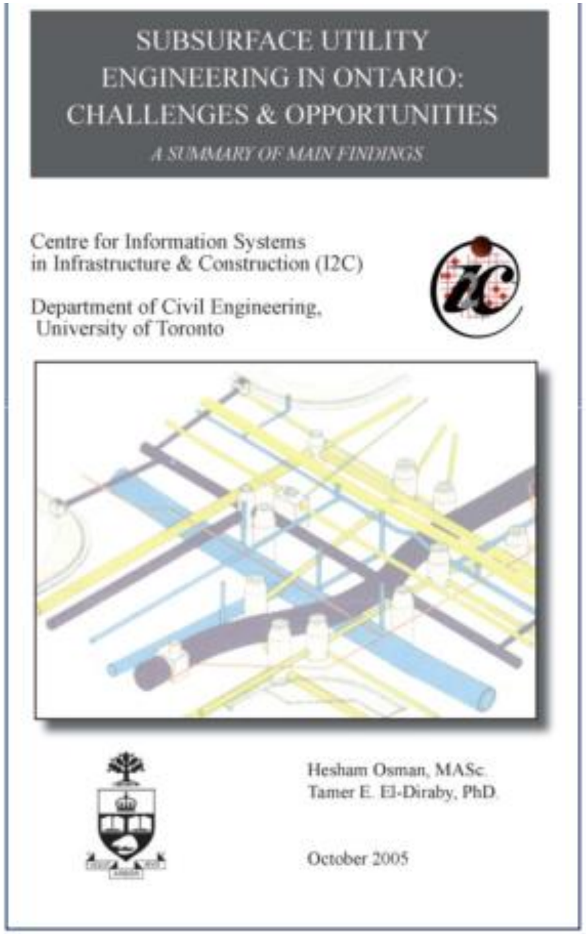
Prepared for the
Federal Highway Administration
Office of Program Administration
Washington, D.C.

FHWA Contract Number DTFH61-96-C-00090

- Purdue University
- Commissioned by Federal Highway Administration FHWA.
- $4.62 return on $1.00 investment

In Numbers……

- University of Toronto
- Commissioned by Ontario Sewer and Watermain Contractors Assoc.
- $3.41 return on $1.00 investment

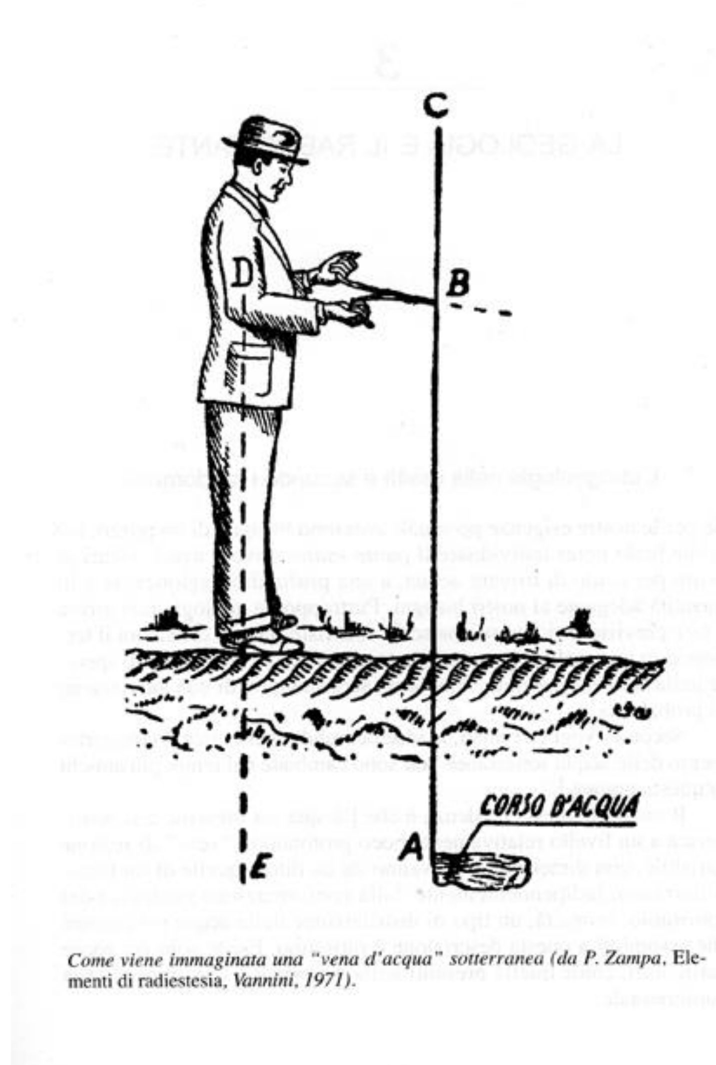


Utility Mapping Standards / SUE
Subsurface Utility Engineering

Name	Country	Year
Various	Various	From the 18^{th} century
ASCE Standard 38-02	USA	2003
Malaysia Standard Guideline for Underground Utility Mapping	Malaysia	2006
CSA Standard S250	Canada	2011
Standards Australia Committee AS 5488-2013	Australia	2013
British Standards Institute PAS 128	United Kingdom	2013 - 2014
Ecuadorian Institute for Standardization NTE INEN 2873	Ecuador	2015
UNI - Prassi di Riferimento 26 1 2017	Italy	2016

Before 2003

Before 2003



Come viene immaginata una "vena d'acqua" sotterranea (da P. Zampa, Elementi di radiestesia, *Vannini, 1971).*

Before 2003

TELECOM ITALIA

DIREZIONE GENERALE

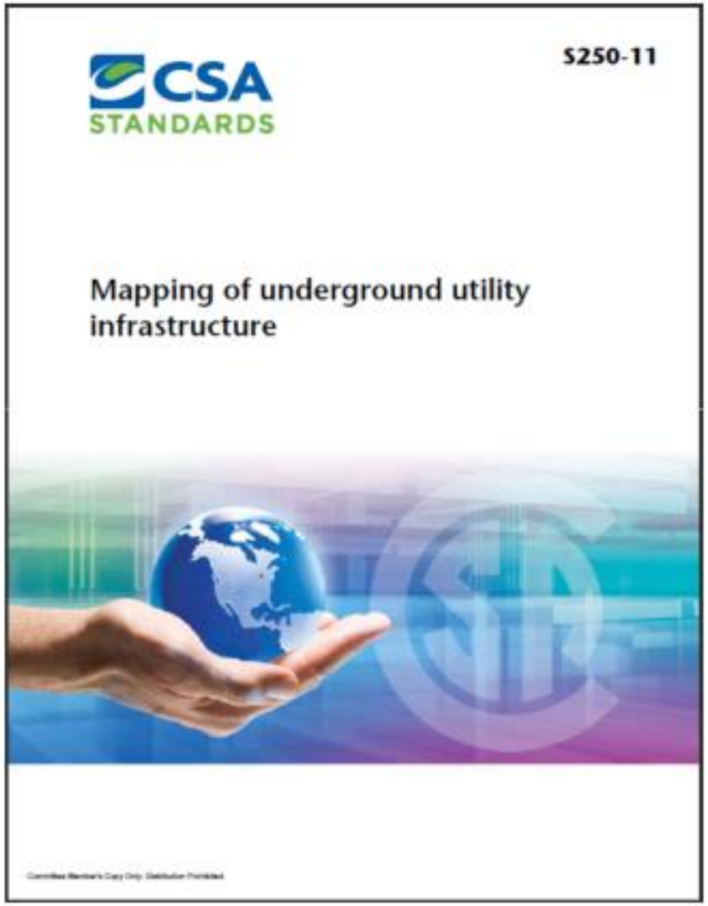
ISTRUZIONI PER L'IMPIEGO DEL RADAR PER INTROSPEZIONE DEL SUOLO PER PROSPEZIONI PRELIMINARI AD OPERE DI POSA

DRE/IR-ICM

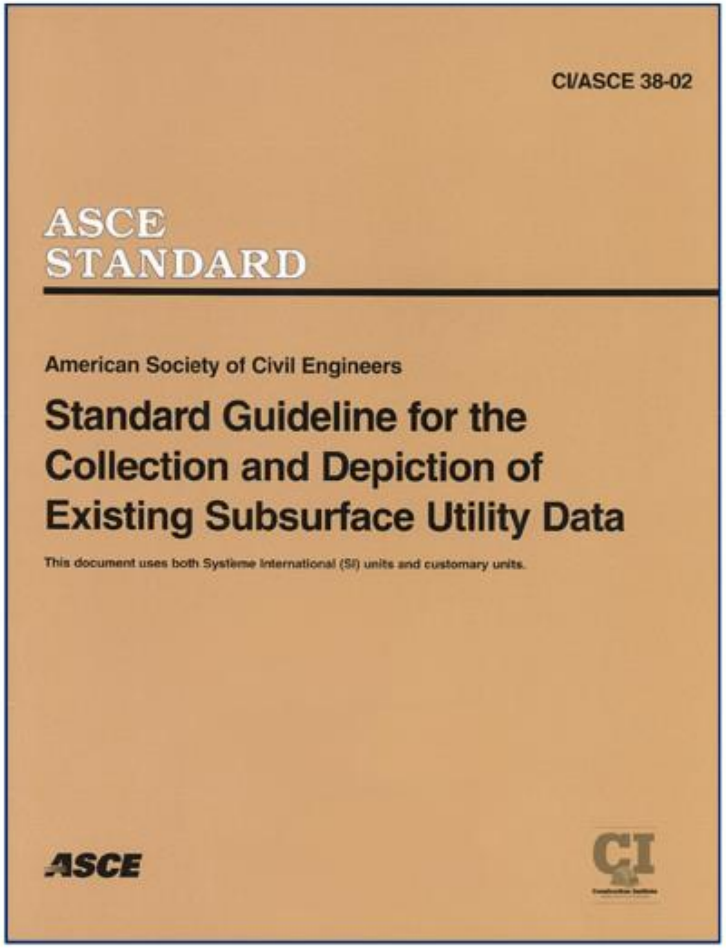
Roma, Maggio 1997

Purpose of a Standard for utility mapping

- Define a clear classification of different achievable results based on different surveying methods;
- Push a dialogue between Surveyors, Engineers and Project managers, in relation to the level of detail and effort to be used within a project;
- Provide a tool for the integration of dataset with different reliability and quality level;
- Disseminate a protocol to increse the quality of undergroung surveys.



2003 first official Standard Guideline by ASCE the American Society of Civil Engineers

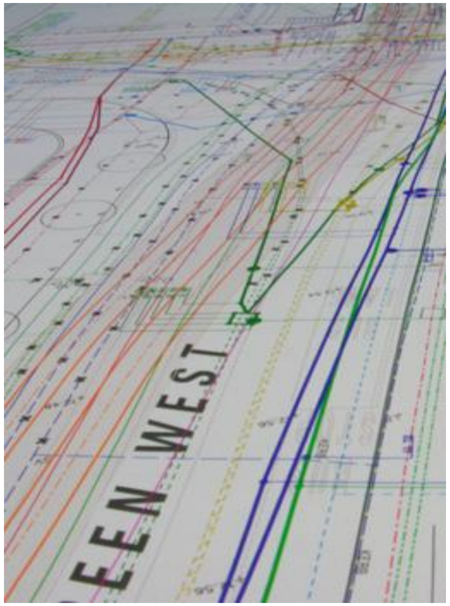


A shared approach

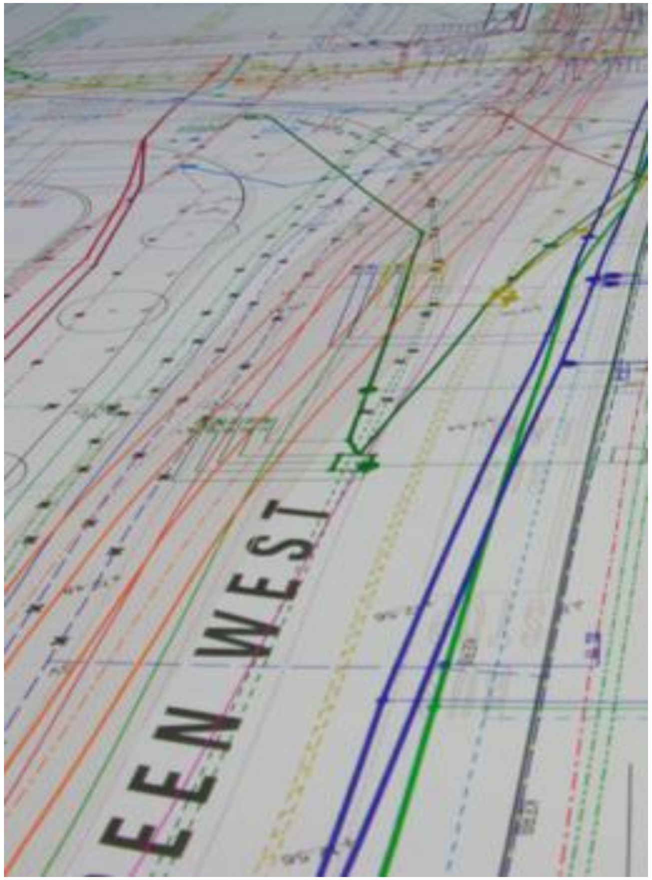
- USA
- Canada
- Australia
- Malaysia
- United Kingdom
- Italy

The 4 Different Quality Levels

ASCE Standard

Level D	Level C	Level B	Level A
			

"Quality Level D" is the least reliable data

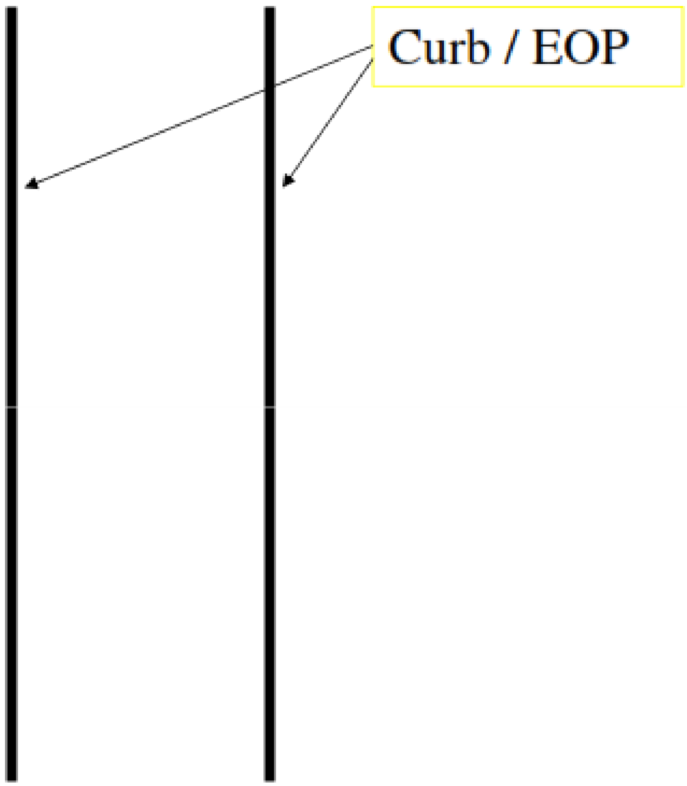


- Plans are defined from data records;
- Plans can also be integrated with verbal data recollection;
- Sometimes the surveyor perform a site visit to better understand the utility layout.

Note:

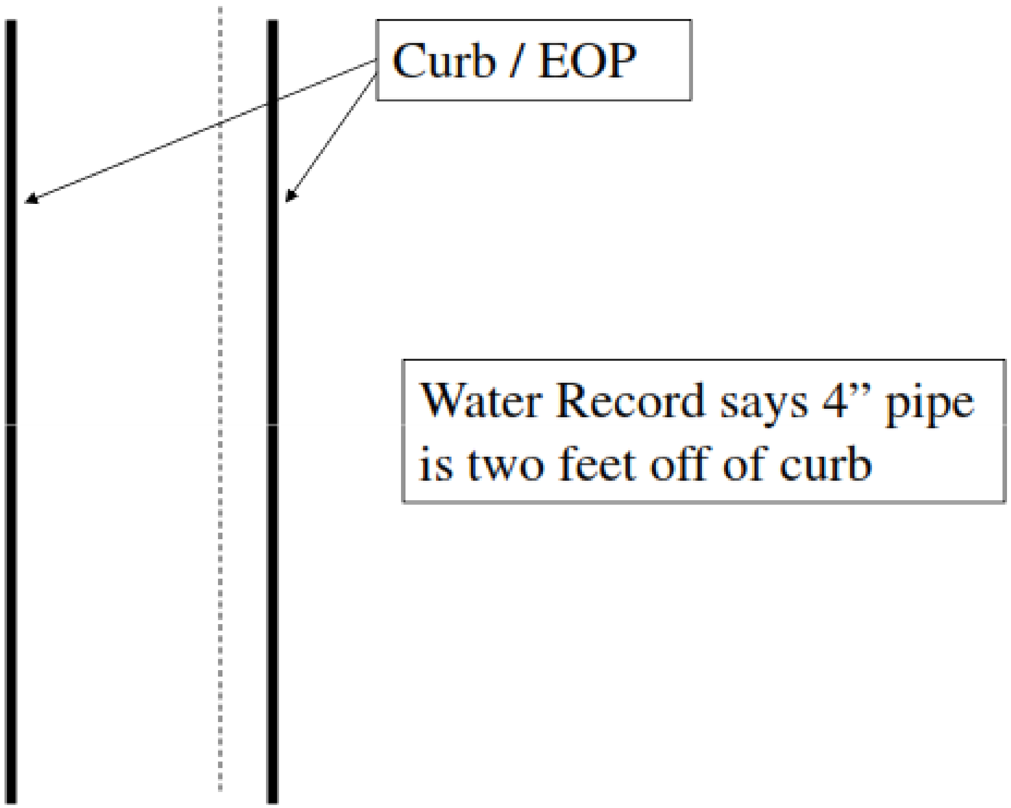
Quality Level D is normally used for planning or preliminary investigation.

Quality Level D



EOP = Edge of Pavement

Quality Level D



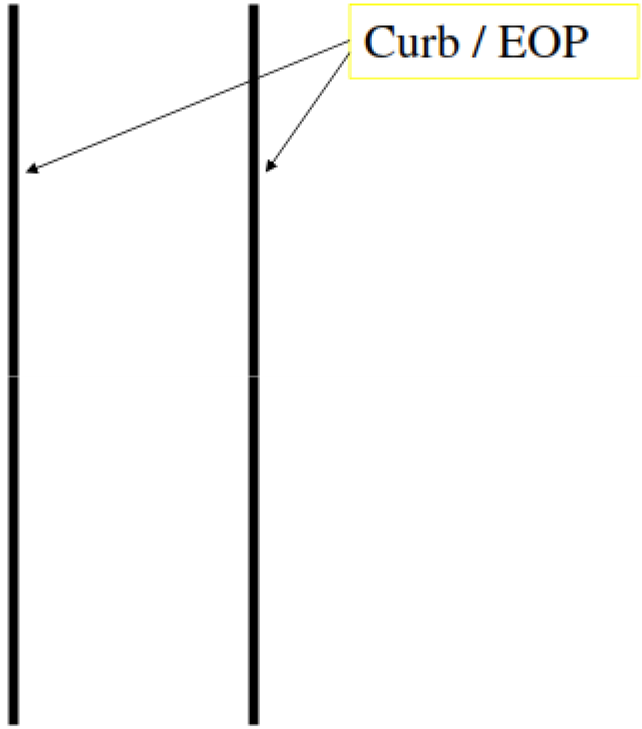
"Quality Level C" is the traditional mapping method

- All the surface apparatus related to underground utilities are topographically surveyed and integrated in the map plan;
- All the data acquired with Quality Level D is related / correlated with the surveyed data

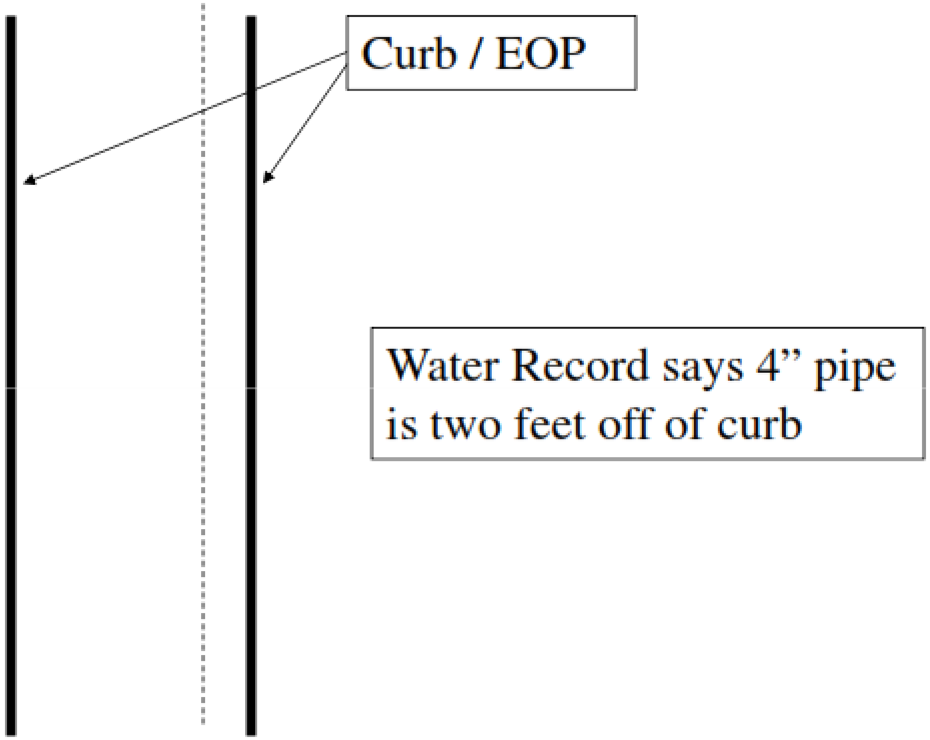
Note:

Quality Level D is normally not much reliable. Often pipes don't go straight and very often the utility records are not present.

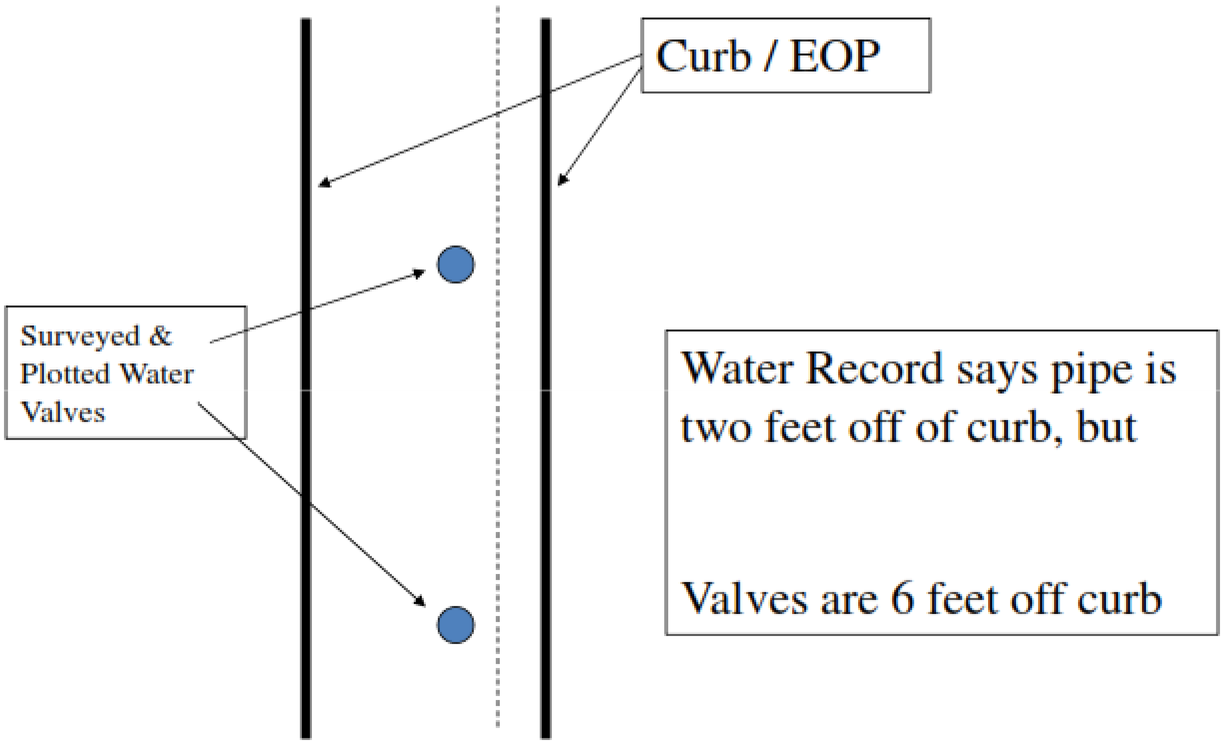
Quality Level C



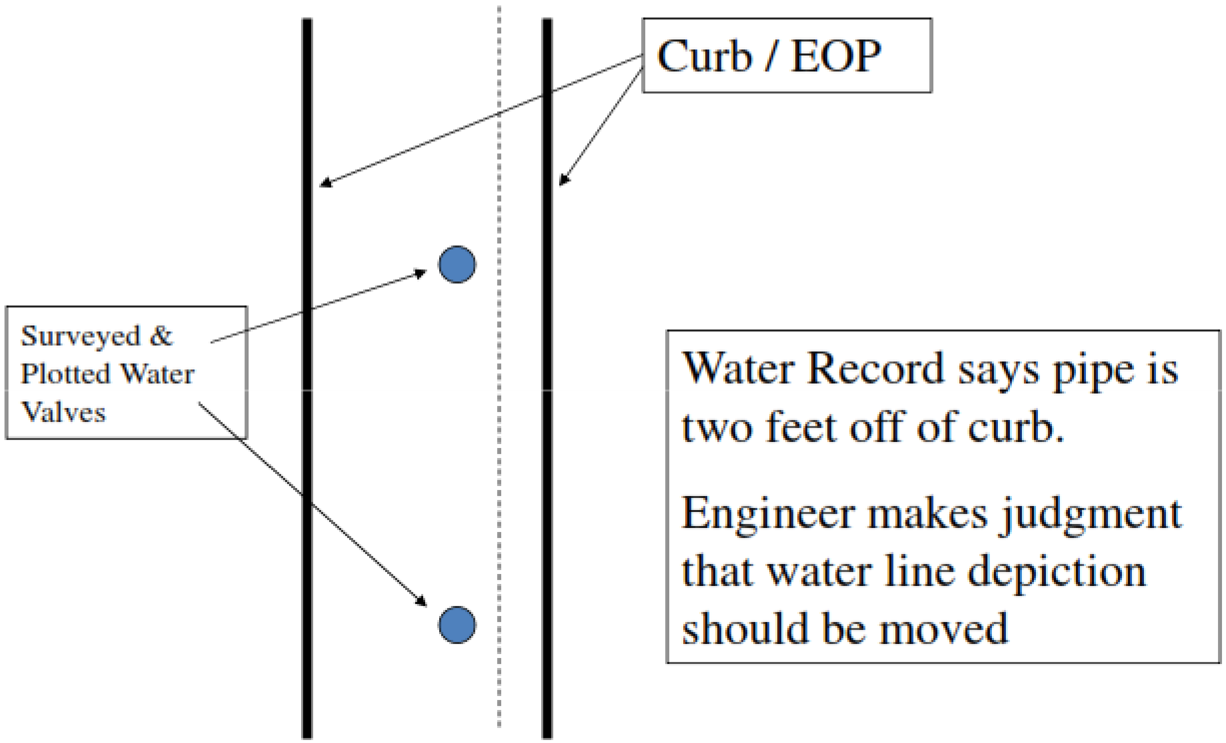
Quality Level C



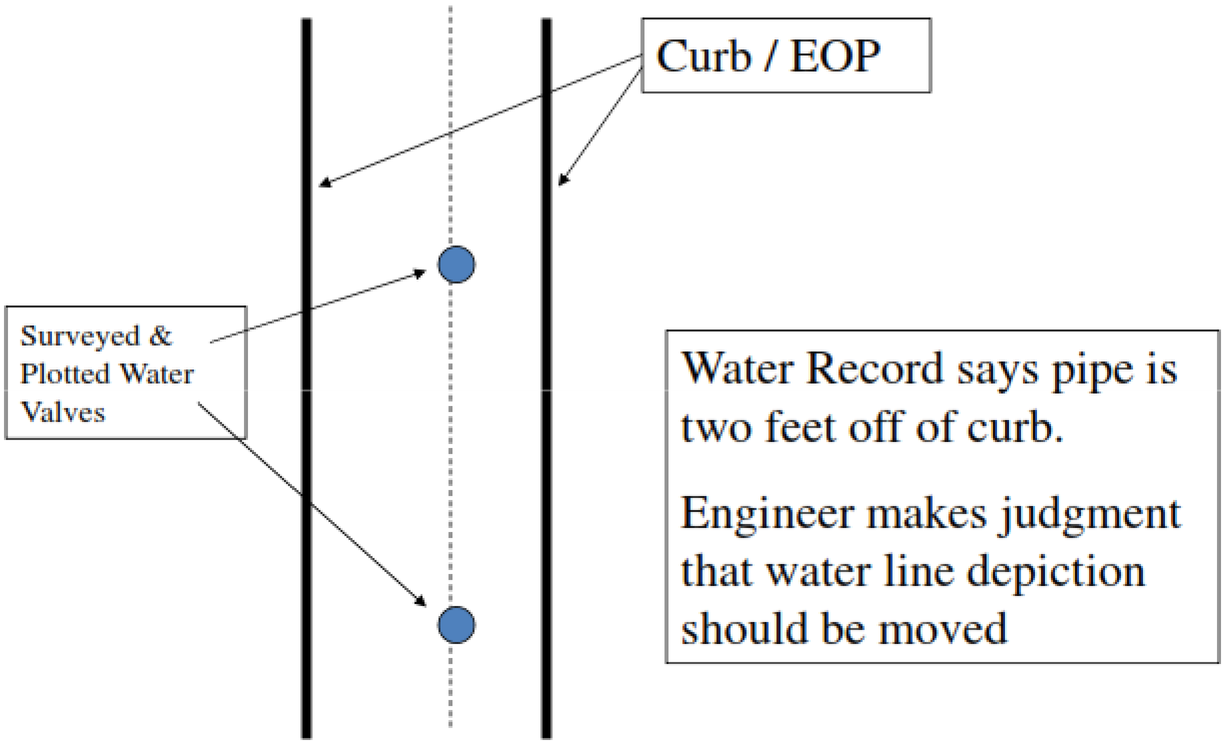
Quality Level C



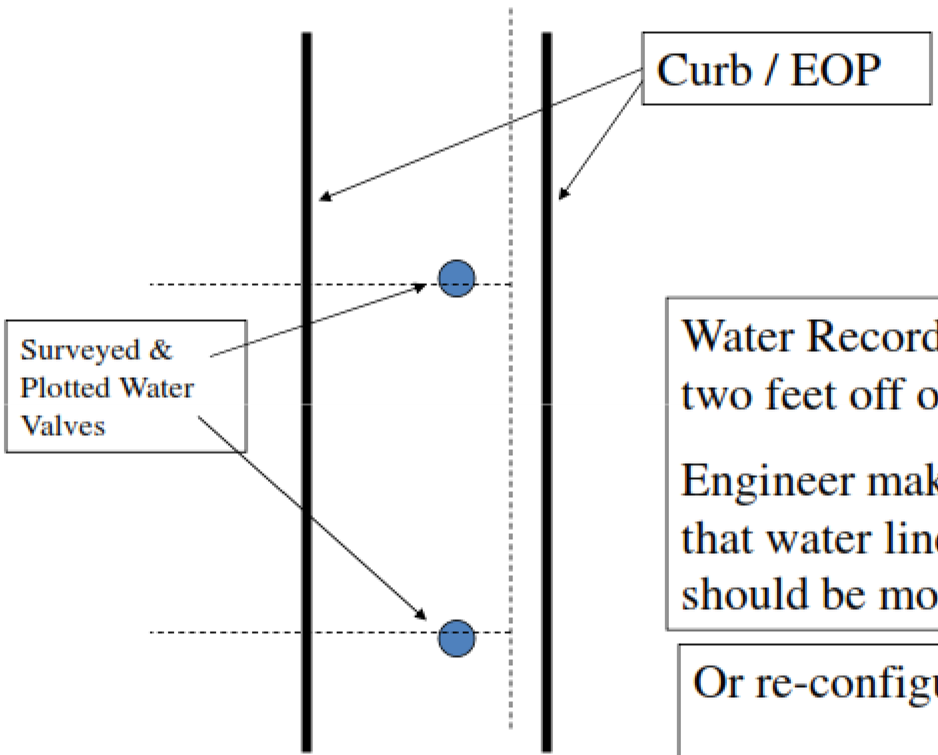
Quality Level C



Quality Level C



Quality Level C



Water Record says pipe is two feet off of curb.

Engineer makes judgment that water line depiction should be moved.

Or re-configured.

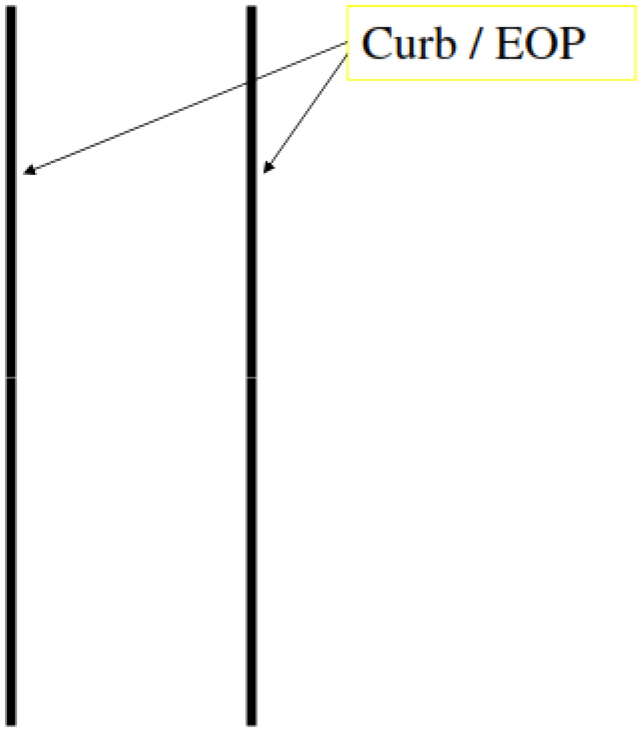
"Quality Level B" a great increase in quality level from QLC

- Geophisical Instrument are used to survey the buried utilities. Target detected with GPRs are inserted in the map.

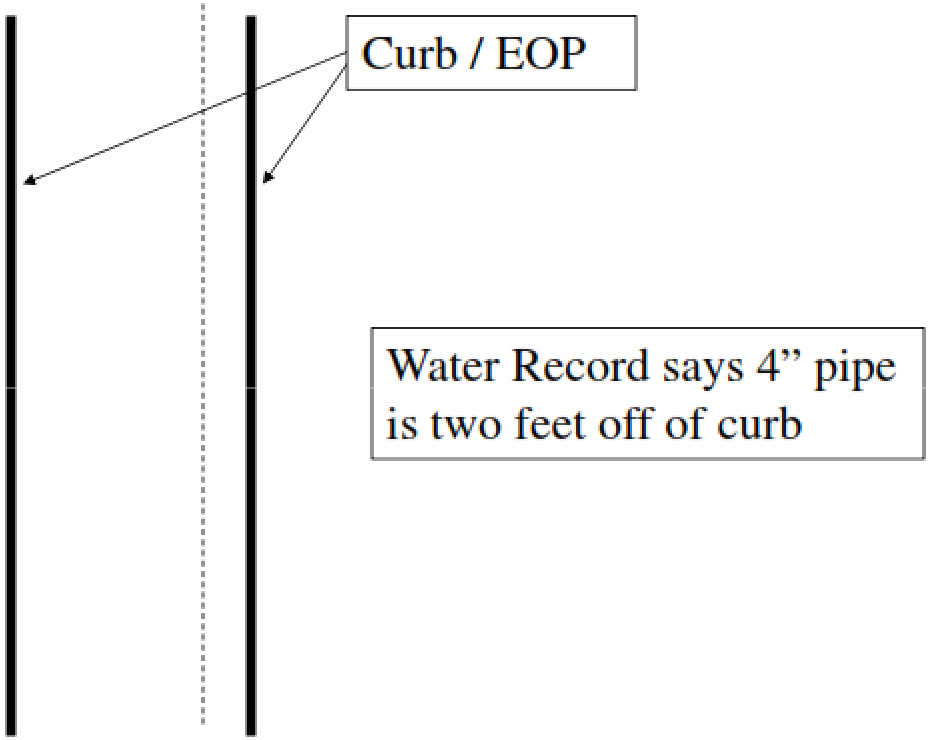
Note:

Quality Level B a big step ahead compared to the previous levels. With this quality level it is possible to map all the pipes even if not in records.

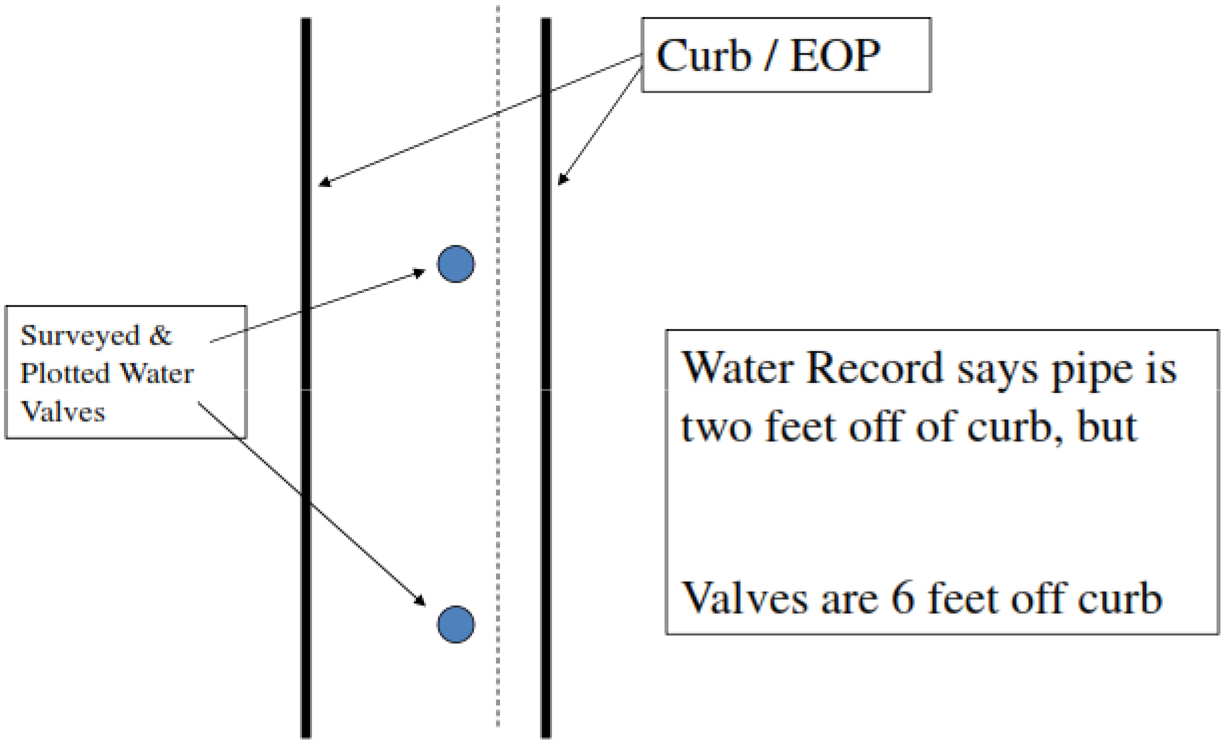
Quality Level B



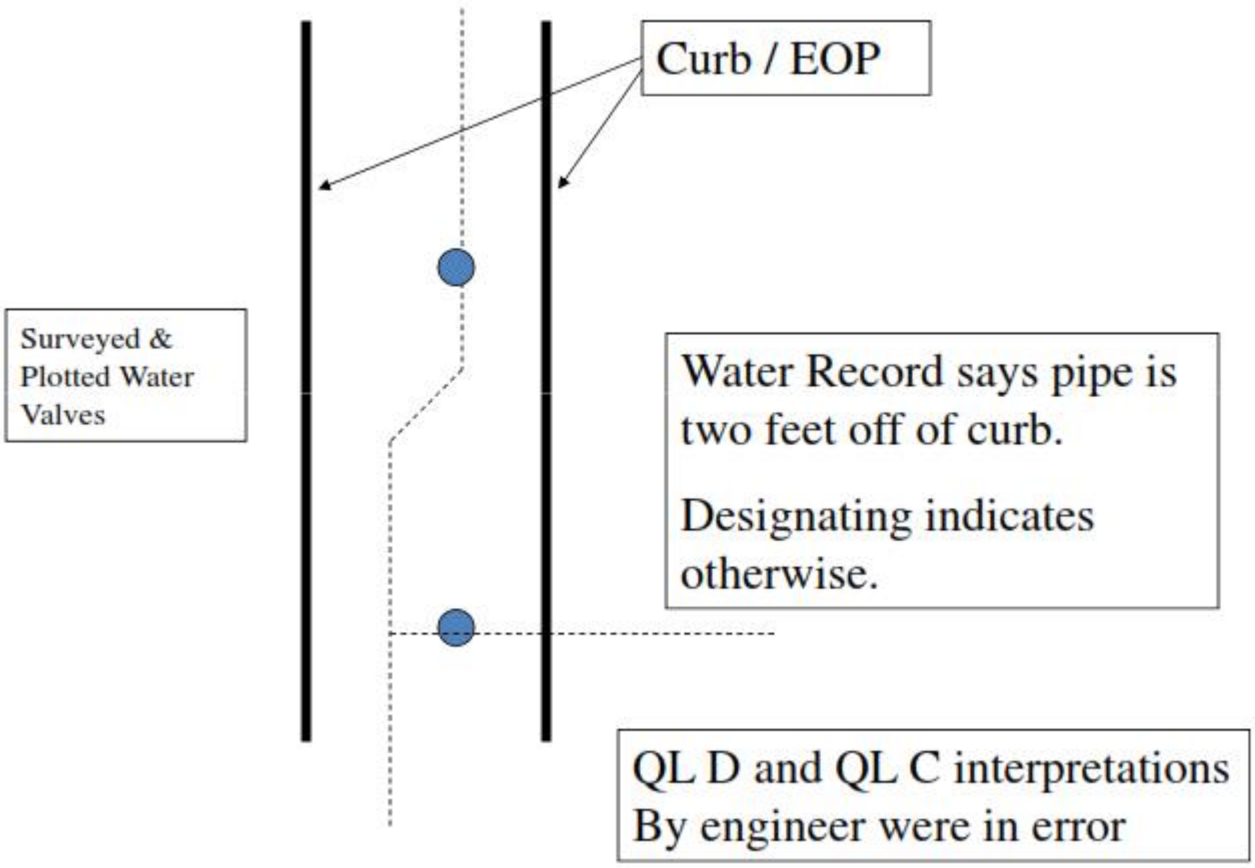
Quality Level B



Quality Level B



Quality Level B



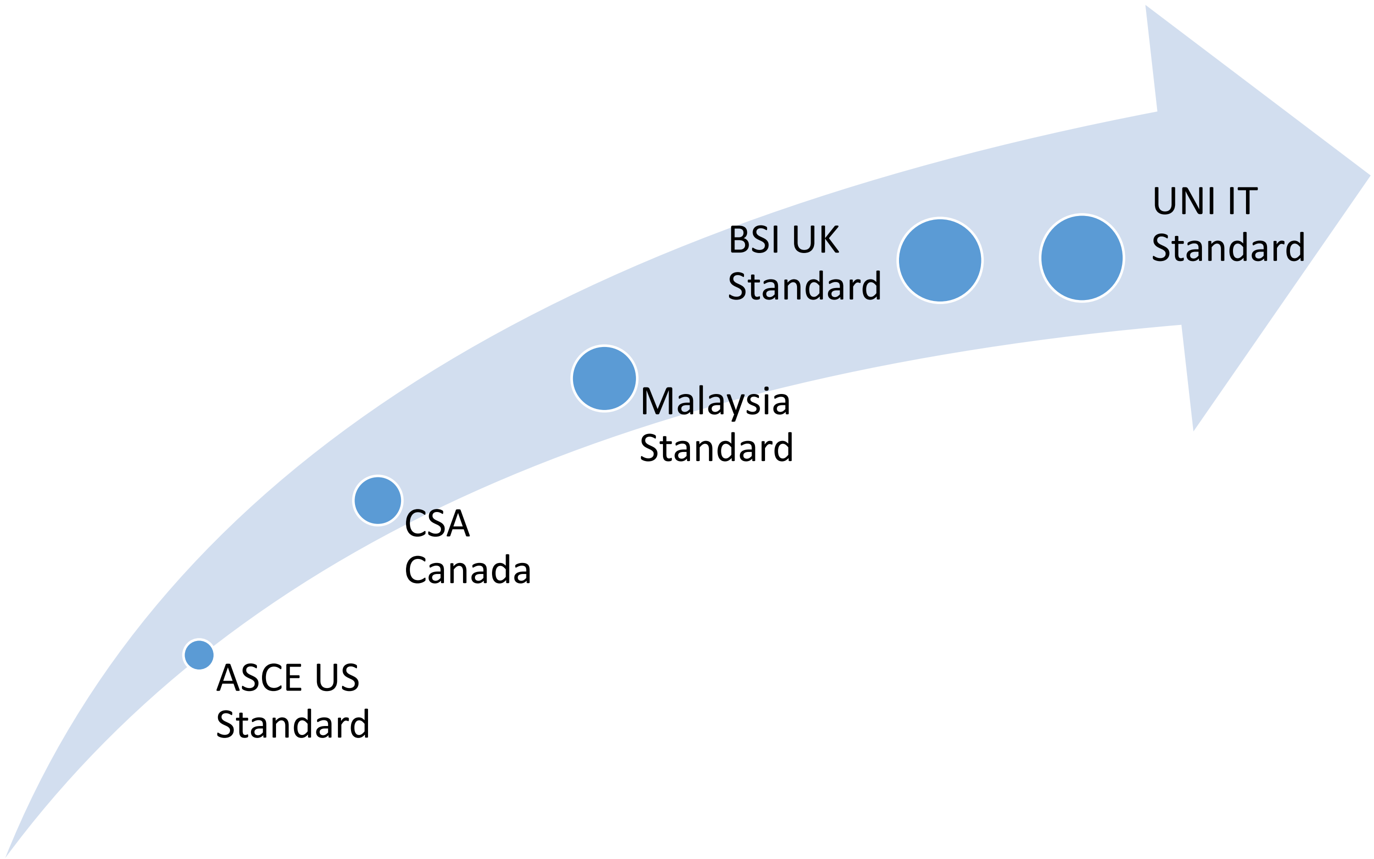
"Quality Level A" is the most reliable data

- Utility exposed using Vacuum Excavation technology or in alternative traditional digging technologies;

Note:

Exposing the pipes reveals also: constructon materials; size; asset condition, and precise depth.

An Evolving Standard



Malaysia Standard VS ASCE Standard

Comparing main features of Quality Level D

Malaysian Standard	ASCE
Quality level D	Quality level D
• Utility record search • Visual site inspection • Prepare utility composite drawings	• Utility record search • Prepare utility composite drawings

Malaysia Standard VS ASCE Standard

Comparing main features of Quality Level C

Malaysian Standard Quality level C	ASCE Quality level C
No real difference	

Malaysia Standard VS ASCE Standard

Comparing main features of Quality Level B

Malaysian Standard	ASCE
Quality level B	Quality level B

No real difference

Comparing main features of Quality Level A

Malaysian Standard Quality level A	**ASCE** Quality level A
• Accuracy specified at 10cm (vertical and horizontal) • Exposure of the underground utility as necessary	• Elevation accuracy 15mm • Excavate test holes

UK BSI PAS 128

Table 1 – Quality level of survey outputs (normative)

Survey type (Establish with client prior to survey)		Quality level (Practitioner to determine post survey)	Post-processing	Location accuracy		Supporting data
				Horizontal [1]	Vertical [2]	
D	Desktop utility records search	QL-D	—	Undefined	Undefined	—
C	Site reconnaissance	QL-C	—	Undefined	Undefined	A segment of utility whose location is demonstrated by visual reference to street furniture, topographical features or evidence of previous street works (reinstatement scar).
B	Detection [3]	QL–B4	No	Undefined	Undefined	A utility segment which is suspected to exist but has not been detected and is therefore shown as an assumed route.
		QL-B3	No	±500 mm	Undefined (No reliable depth measurement possible)	Horizontal location only of the utility detected by one of the geophysical techniques used.
		QL-B3P	Yes			
		QL-B2	No	±250 mm or ±40% of detected depth whichever is greater	±40% of detected depth	Horizontal and vertical location of the utility detected by one of the geophysical techniques used. [4]
		QL–B2P	Yes			
		QL-B1	No	±150 mm or ±15% of detected depth whichever is greater	±15% of detected depth	Horizontal and vertical location of the utility detected by multiple [5] geophysical techniques used.
		QL–B1P	Yes			
A	Verification	QL-A	—	±50 mm	±25 mm	Horizontal and vertical location of the top and/or bottom of the utility. Additional attribution is recorded as specified in **9.2.5**.

[1] Horizontal location is to the centreline of the utility.
[2] Vertical location is to the top of the utility.
[3] For detection, it is a requirement that a minimum of GPR and EML techniques are used (see **8.2.1.1.2**).
[4] Electronic depth readings using EML equipment are not normally sufficient to achieve a QL-B2 or higher.
[5] Some utilities can only be detected by one of the existing detection techniques. As a consequence, such utilities cannot be classified as a QL-B1.

IT UNI Standard

UNI/PdR 26.1:2017

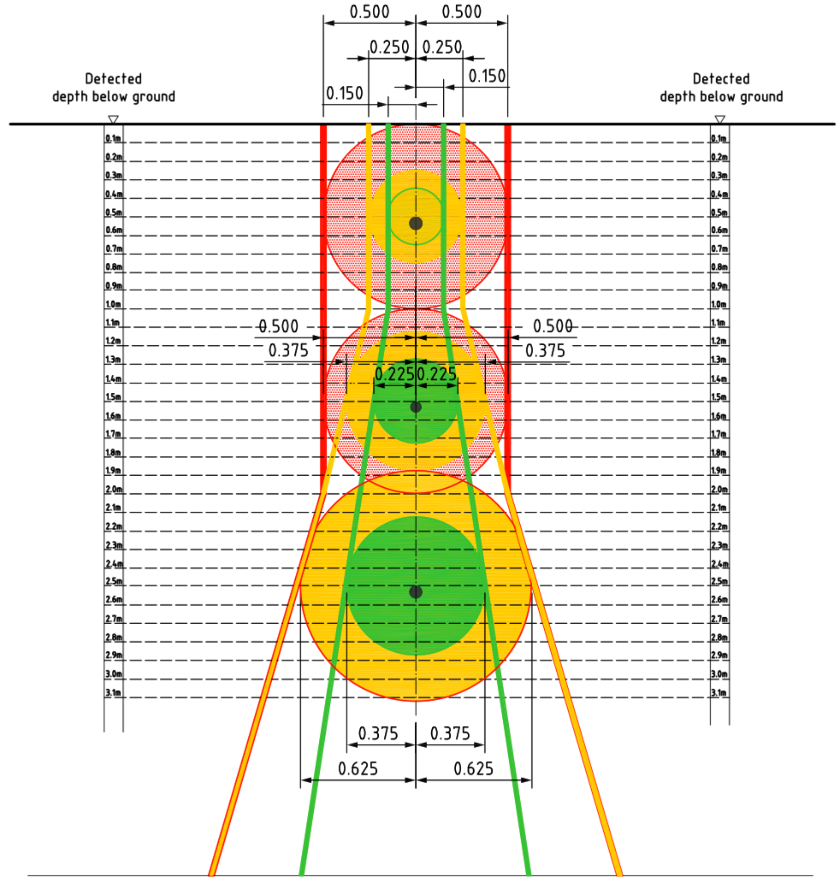
Table 1 - Classification of quality levels

Quality level	**Sublevel**	**Data origin**	**Error range on the horizontal floor variable according to the various ranges of depth**					**maximum error % on the depth of the investigation**	**Materials**
			(0 - 0,5) m	**(0,5 - 1,0) m**	**(1,0 - 1,5) m**	**(1,5 - 2,0) m**	**(2,0 – 3,0) m**		
LQ-D	**---**	Collection of available historical archives, information obtained orally	Non defined	Non defined	Non defined	Non defined	Non defined	Non defined	
LQ-C	**---**	Auditing from in situ inspection by means of topographic measurements	Non defined	Non defined	Non defined	Non defined	Non defined	Non defined	
LQ-B	**LQ-B-II**	Services localized by means of georadar systems without data processing, also combined with the use of electromagnetic detectors to check conductor services. In the areas of high density of underground utilities, this quality level is not applicable.	200 mm	300 mm	400 mm	500 mm	600 mm	40%	
	LQ-B-I	Services localized by means of georadar systems with data processing and marks recording chosen on databases of file logs (registers) for subsequent elaboration. In areas with high density of underground utilities, the combined use of electromagnetic detectors to check on conductor services is advisable.	35 mm	75 mm	125 mm	250 mm	400 mm	15%	Insulating materials *
			25 mm	35 mm	75 mm	125 mm	200 mm	10%	Conductor materials **
LQ-A	**---**	Exposure of the service through direct access from manholes or through excavation.	Linked to the accuracy of the measurement equipment used						

* Polyethylene with gas or vacuums, concrete, other plastic materials, TLC cables without metallic reinforcement
** Iron pipes, cast iron, electric cables, TLC cables with metallic reinforcement

UK BSI PAS 128

Figure A.1 – Chart of horizontal and vertical accuracy for QL-B (informative)



Key

- QL-B1 or QL-B1P, ±15% of depth or 0.15 m (whichever is greatest)
- QL-B2 or QL-B2P, ±25% of depth or 0.25 m (whichever is greatest)
- QL-B3 or QL-B3P, detection successful but no depth, horizontal ±0.50 m

***NOTE** The accuracy decreases beyond 2.00 m depth.*

- Utility with 63 mm diameter

24

UNI/PdR 26.1:2017

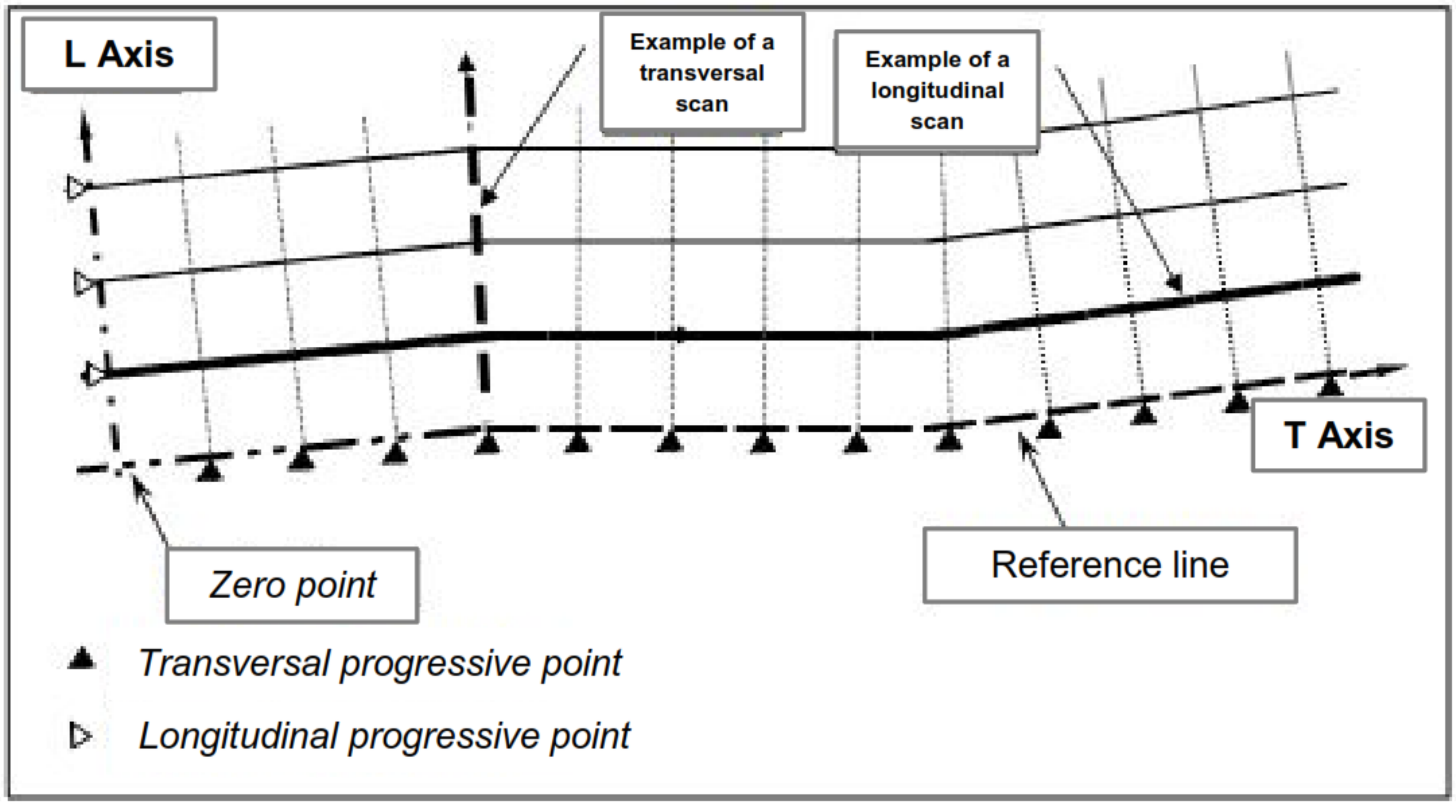


Figure 7 - Definition of the reference system

Standards are not to be considered a limit

Questions and answers !!!

Thank you !!

Contact Enrico Boi:

Email: e.boi@idsgeoradar.com

Utility Detection and Mapping using GPR

Coordinators:

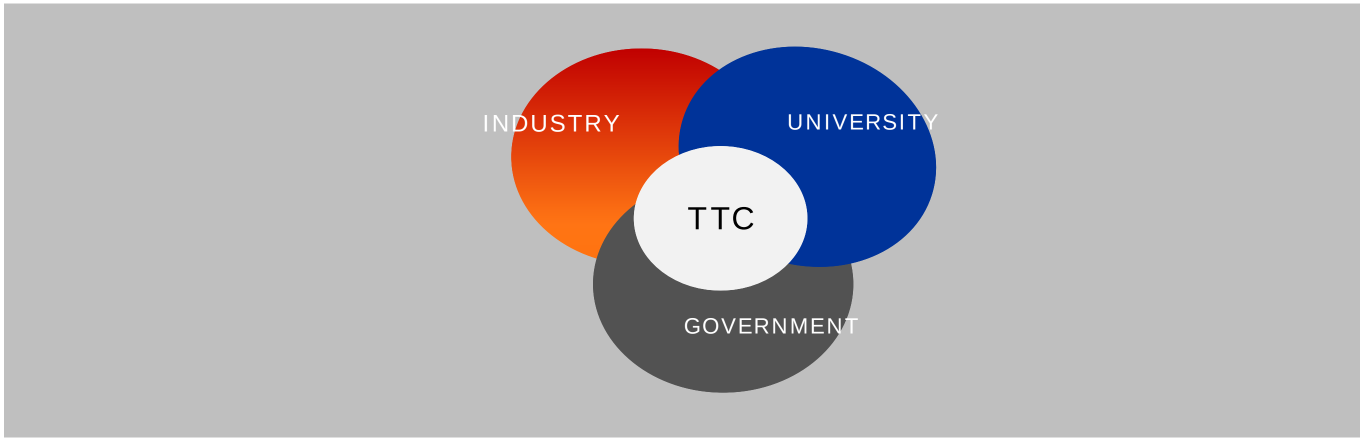
Dr. Tom Iseley, P.E., Dist. M. ASCE
Professor, Louisiana Tech University
Assoc. Director of International Operation, Trenchless Technology Center (TTC)

Enrico Boi
President at IDS Georadar North America

Overview of TTC

TTC is expanding the research focus on integration of trenchless technology into asset management and continues to grow research programs to further increase understanding of the fundamental performance issues associated with various trenchless methods.

Louisiana Tech University
Trenchless Technology Center
From 1989-2017

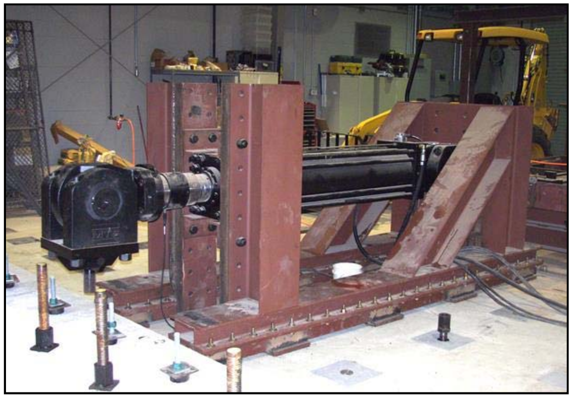


• Research • Education • Technology Transfer

National Trenchless Technology Research Facility (NTTRF)

Facilities

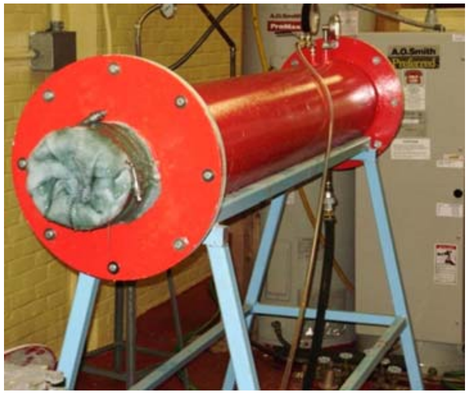
Inside NTTRF



Servo-controlled hydraulic ram, large

Soil box (small 12'x6'x6', large 10'x20'x11')

Extruder for cementitious samples

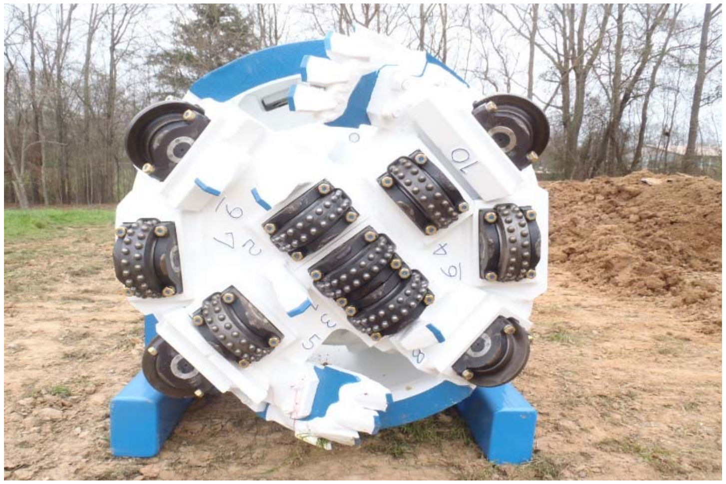


Liner Inversion Chamber

Field Testing Site

Approximately 70,000 sq. ft. for a variety of field tests related to HDD, pipe bursting or other trenchless method research

TTC Auger Boring School



The 3rd Annual TTC

Auger Boring (AB), Pipe Jacking (PJ) &

Pilot Tube Microtunneling (PTMT) School

Feb 5-9, 2018

The 2nd TTC Utility Investigations School (UIS)

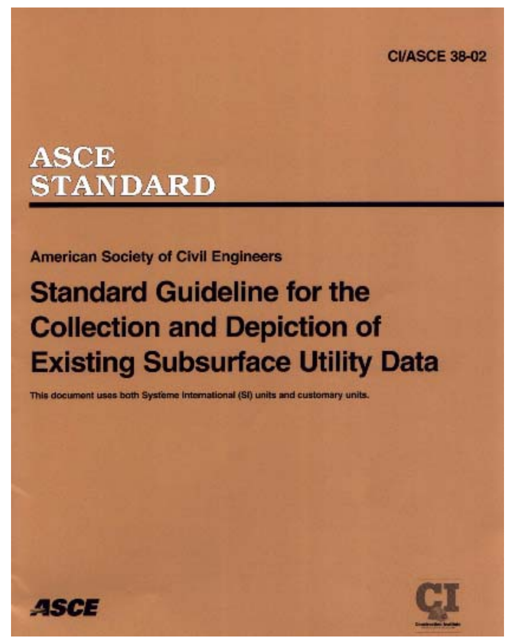
February 26-March 2, 2018

TRENCHLESS TECHNOLOGY CENTER

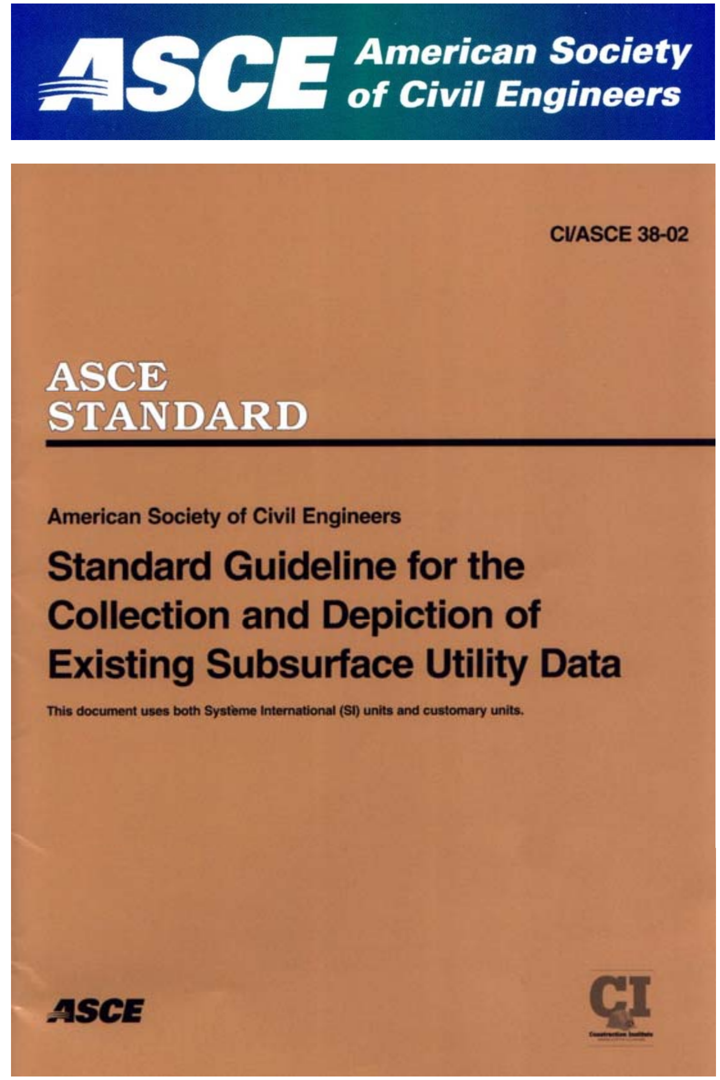
UESI ASCE

DEPARTMENT OF LAND SURVEYING AND GEO-INFORMATICS 土地測量及地理資訊學系

THE HONG KONG POLYTECHNIC UNIVERSITY 香港理工大學



- Outlines specific steps for the engineer / surveyor to take that result in increasingly better utility mapping.
- Utilities as mapped are shown according to their “Utility Quality Level” which allows all parties to make better risk decisions.
- Use of Utility Quality Levels protects engineers and surveyors
- Requires all utility mapping to be performed under the direct responsible charge of a registered professional, experienced in utility issues, surface geophysics, survey, and depiction methods
- Increasing usage across the country is increasing its importance in cases where standard of care is an issue.



Trenchless Technology Center

ASCE 38

- Now referenced routinely in 40+ State DOTs
- Best practice (FHWA, APWA, CGA, FAA, National Academy of Science, and others)
- Case Law increasing
- Referenced as part of state statute in PA, MN
- 2nd Best selling ACSE standard behind ASCE 7
- Update imminent
- Used as basis for new standards in UK, NZ, Malaysia, Canada, Australia, and Ecuador (pending).
- JUST IN: ASCE 38 NOW MANDATED IN EJCDC ENG. DOCS

TTC Subsurface Utility Locating with GPR
August 23, 2017

Common Ground Alliance (CGA)

March 6-8, 2018

- The **CGA 811 Excavation Safety Conference & Expo** is the premiere international event dedicated to providing educational content and resources to help protect buried assets.
- The Conference, owned and produced by **Infrastructure Resources, LLC**, is the largest event in the underground damage prevention industry, drawing almost 2,000 participants and offering over 60 educational sessions, comprehensive workshops, numerous networking events, and over 100 exhibitors.
- The Common Ground Alliance (CGA) also holds their annual meeting at this event.

Pipe Breaks




AM Water & Sewer

Definition

Address customers' immediate service requirements while managing the system assets to meet long-term requirements reliably & cost effectively

Long-term AM results in:

- **Increased Asset Life**
- **Decreased Maintenance Costs**
- **Decreased Capital Costs**
- **Permits planned spending based on critical needs.**
- **Allows scarce financial resources to be effectively used.**
- **Potentially increases revenues by revealing opportunities to sell or lease land or retired assets, sell excess capacity, provide outside services, or initiate new business.**

Asset Management Strategies

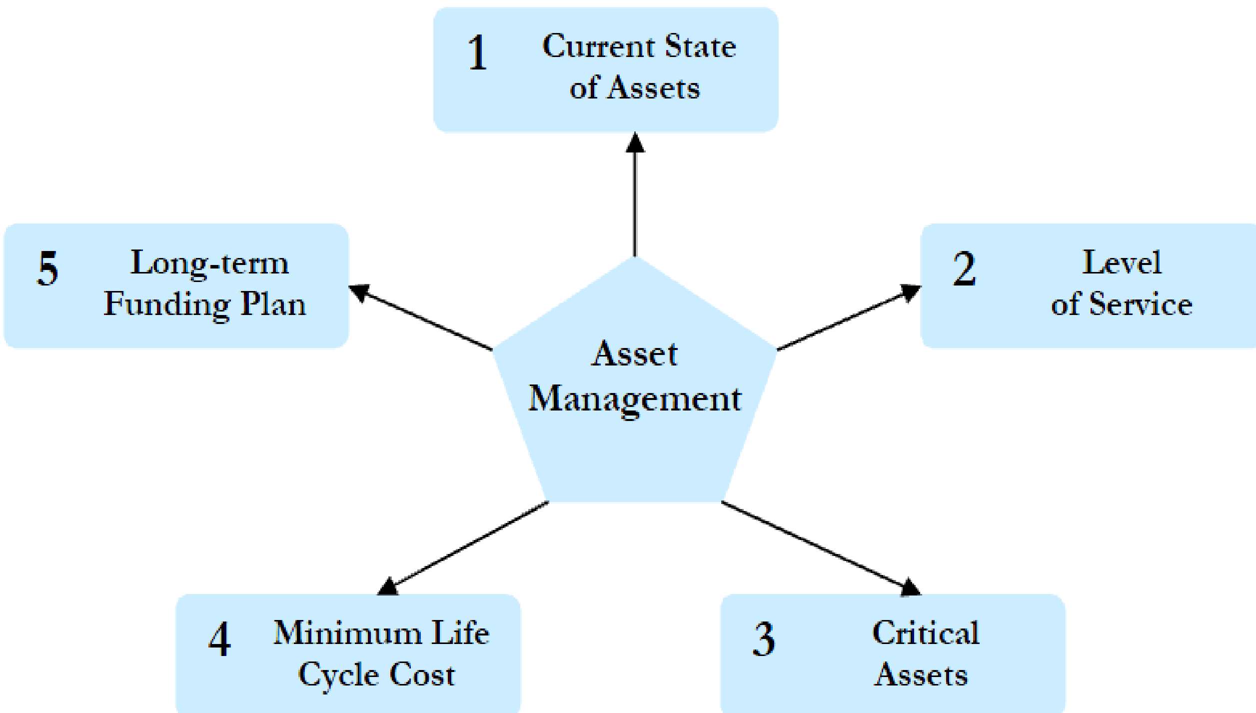
Asset Management:

It is maintaining a desired level of service for what you want your assets to provide at the lowest life cycle cost. Lowest Life cycle cost refers to the best appropriate cost for rehabilitating, repairing or replacing an asset.

Resource: EPA Asset Management Best Practices

Asset Management Strategies

Five Core Questions of Asset Management Framework



Resource: EPA Asset Management Best Practices

Asset Management Strategies

1- What is current state of my assets?

- What assets do we have – Inventory
- Where are they located - Mapping
- What are their condition - PCA
- Determine remaining life
- Determine renewal/replacement cost & date




Asset Management Strategies

Asset Manager Needs to Know

1

Corrosion with Graphitization
Eroded the CIP Wall

2

Corrosion Pitting Can
Produce a Hole

3

It Resulted in Blowout
Section Mode of failure

The Cost of Water

Let's Compare: Monthly Bills in the USA…..

Description	Monthly Bill	Source
Average Water & Sewer (2017 $)	**$85**	**AWWA**
Average cell phone (2009 $)	$71 adjusted to 2017= **$85**	J.D. Power & Assoc.
Average cell phone (2015 $)	$110 adjusted to 2017 = **$115**	Gazelle News
Average Cable TV (2016 $)	**$103**	Fortune 500

The Cost of Water

- ASCE Estimates it will cost about $1.3 trillion to upgrade our water and wastewater infrastructure over the next few decades
- And, this really does not include everything
- ASCE Average Report Card Grade for Water and Wastewater over the last 15 years = D
- Reason: <u>Delayed Maintenance and underinvestment</u>
- ***The Average American is willing to pay more for their cell phone or cable TV than safe drinking water and proper sanitation***

AM: Origins in the Utility Industry

- 1972 Clean Water Act (*PL 92-500*)
  - Launched NPDES *(National Pollutant Discharge Elimination System)*
  - First steps towards SSES *(Sewer System Evaluation Survey)*

- AM Continued Advancement
  - CMOM *(Capacity, Management, Operation, Maintenance Program)*
  - GASB 34 *(General Accounting Standards Board) -* requirements


Trenchless
TECHNOLOGY
WEFTEC Preview Inside
SEPTEMBER 2003
TRENCHLESSONLINE.COM
Atlanta's Clean Water Advocates
Commissioner Jack Ravan and Mayor Shirley Franklin...
De-Mystifying Asset Management
JEA Tackles Manhole Rehab
Bypass Pumps Meet Rehab Demands

Water & Sewer Champion

Mayor Shirley Franklin – Atlanta's Sewer Mayor

- Atlanta Journal-Constitution – July 15, 2002

Atlanta eager to develop world-class sewer system

- People worldwide dream of living in a community with clean water, plentiful jobs and affordable housing. Over the Next 12 years, Atlanta will make its largest investment ever in such a dream. To assure high water quality and long-term economic stability for ourselves, our children and grandchildren, we are embarking on a $3B sewer improvement program.
- Most of this investment is required under a federal court order --- **it is our opportunity to develop a world-class sewer system (water program)**

The Roadmap to Accomplish the Challenges of Water Utilities Requires AM for Assuring Sustainability

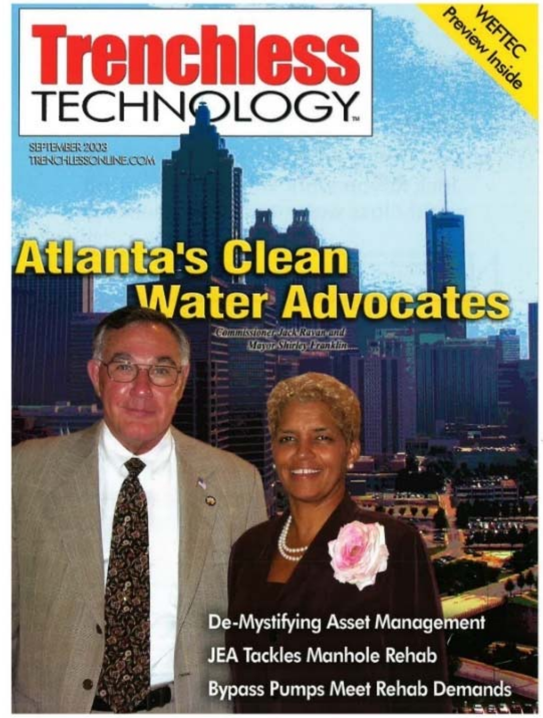
Requires:

- Innovation
- Validation
- Education

BAMI-I
Buried Asset Management Institute - International

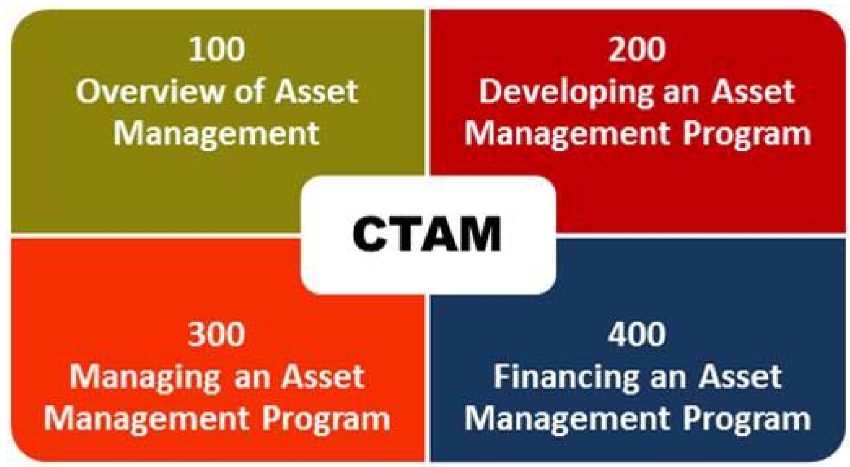
What is CTAM?

- Certification of Training in Asset Management
- Exclusive four-part series training



Levels of Certification

- **Associate Water Asset Manager (AWAM)**
- **Professional Water Asset Manager (PWAM)**



Online Asset Management Training for Water Utility Professionals

Exclusive Four-Part Series in Asset Management Certification

- CTAM-100 – Overview of Asset Management 1
- CTAM-200 – Developing an Asset Management Program 2
- CTAM-300 – Managing an Asset Management Program 3
- CTAM-400 – Financing an Asset Management Program 4

Why offer courses in Asset Management?

The Buried Asset Management Institute-International (BAMI-I) created the Certification of Training in Asset Management (CTAM) program to increase awareness and train utility personnel on the best way to implement and use asset management to extend the life and efficiency of their water and wastewater systems. CTAM is an online educational series for obtaining certification of training in management of underground asset infrastructure.

Levels of Certification

I. **Certificate of Completion** – requires completion of each course

II. **Associate Water Asset Manager (AWAM)** – requires completion of CTAM 100-400 and an application submitted to BAMI-I Asset Management Certification Board

III. **Professional Water Asset Manager (PWAM)** – requires completion of CTAM 100-400, four years of relevant asset management experience and an application submitted to BAMI-I Asset Management Certification Board

Benefits of the CTAM Series

- Expand your knowledge and access to resources to enable you to initiate, continue or improve your own asset management program
- Earn internationally recognized certification in the field of asset management
- Earn 1 CEU / 10 PDHs for each course

CTAM

Certification of Training in Asset Management

CTAM-100 At-a-Glance:

- Sharing Asset Management Knowledge Globally
- Asset Management Overview & Technologies
- Introduction to Appropriate Websites & Tools
- Risk Management
- Government Regulations
- Case Study Examples

CTAM-200 At-a-Glance:

- Underground Infrastructure Asset Management
- Advantages, Rewards, Obstacles & Planning
- Asset Inventory, Organization Strategies & Tools
- Water & Wastewater Condition Assessment
- Data Content, Analysis, Sharing & Distribution

CTAM-300 At-a-Glance:

- Organizational, Legal & Budgeting Considerations
- Developing Priorities & Key Performance Indicators
- Infrastructure Inspection, Mapping & Rehab Methods
- Capacity, Management, Operation & Maintenance
- Asset Worth Value & Life-Cycle Analysis
- Risk-Based Budgeting

CTAM-400 At-a-Glance:

- Financial Challenges & Developing Strategies
- Accounting Principles, Reporting & Budgeting
- Strategic Internal & External Financing Tools
- Public-Private Partnerships and Design-Build
- Level of Service and Capital Improvement Plans
- Life-Cycle Costing
- Case Study Examples

The CTAM program was developed by BAMI-I (Buried Asset Management Institute International) in conjunction with the Trenchless Technology Center at Louisiana Tech and Indiana University-Purdue University at Indianapolis, in partnership with *UIM: Water Utility Infrastructure Management*, and is hosted by the Trenchless Technology Center at Louisiana Tech.

For more information and to register, call 330.467.7588, or e-mail: vminer@benjaminmedia.com

Conference.com/Benjamin/CTAM/CTAM_Home.html

Highlights

- **CTAM-100** has 510 registrants from 15 countries;
- **CTAM-200** has 185 Registrants
- **CTAM-300** has 145 Registrants
- **CTAM-400** has 130 Registrants

Highlights

- **AWAM Certificates**

  101 Issued

- **PWAM Certificates**

  12 Issued

Thanks for your attention!

Questions?

Contact information

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