Concrete Scanning with Ultra Pulse Echo METHOD STATEMENT







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Introduction

Primary Objectives

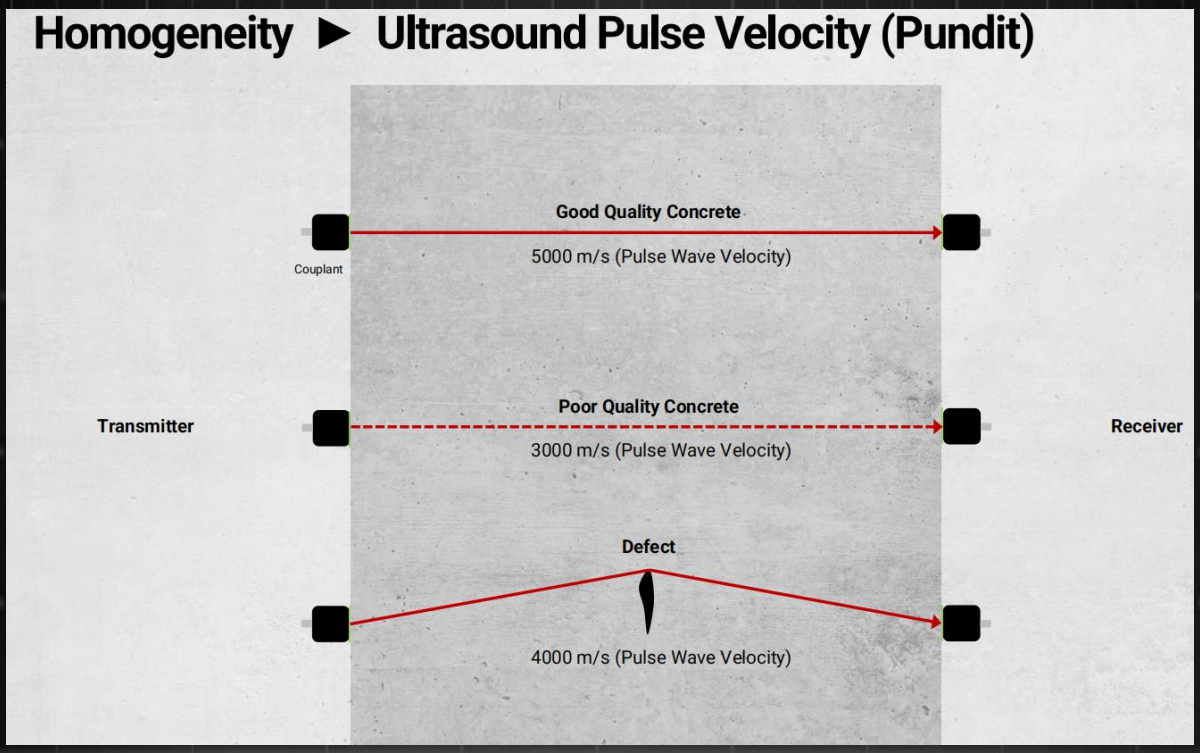
- Evaluate the Homogeneity and quality of the Concrete
- Detect internal defects (flaws, cracks, honeycombing, poor patches)

Secondary Objectives

- Predict the Strength of the Concrete
- Estimate the Depth of Cracks in Concrete
- Estimate Dynamic Modulus of Elasticity of the Concrete

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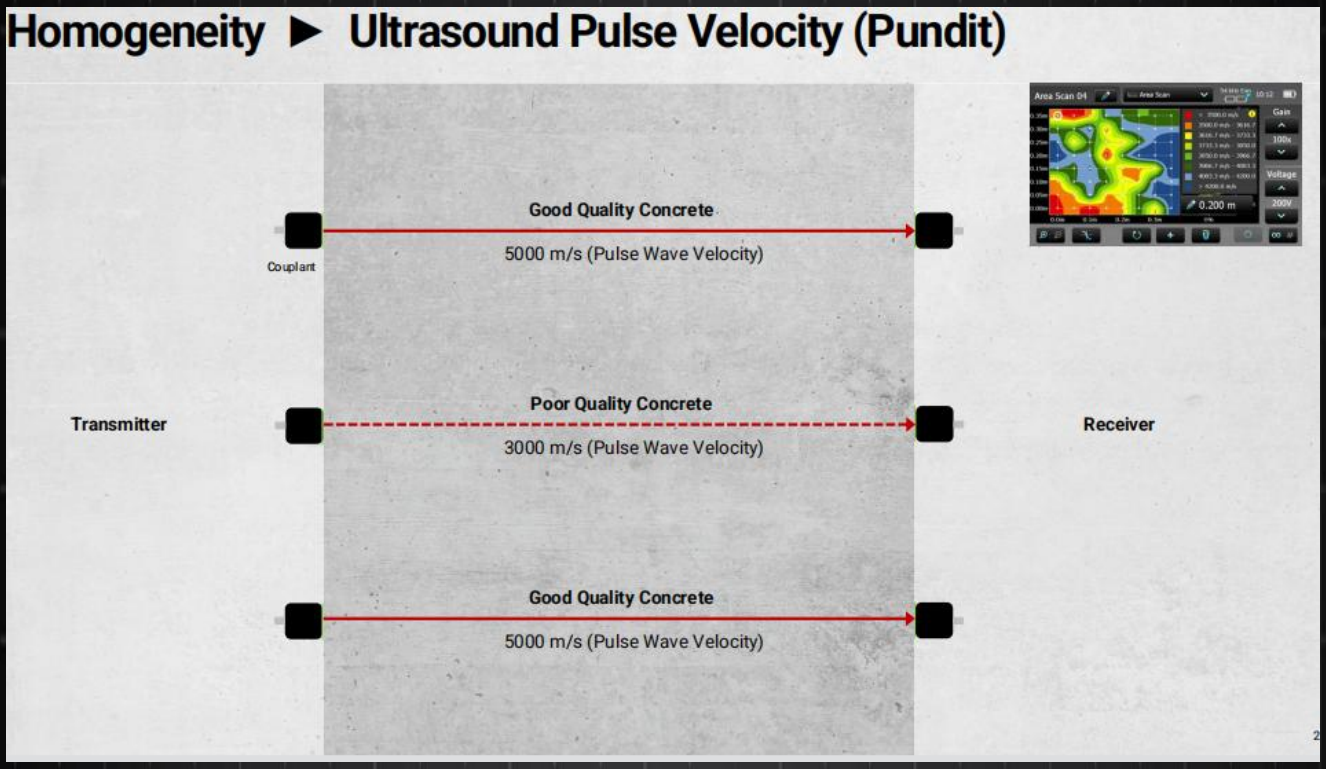
Physical principles



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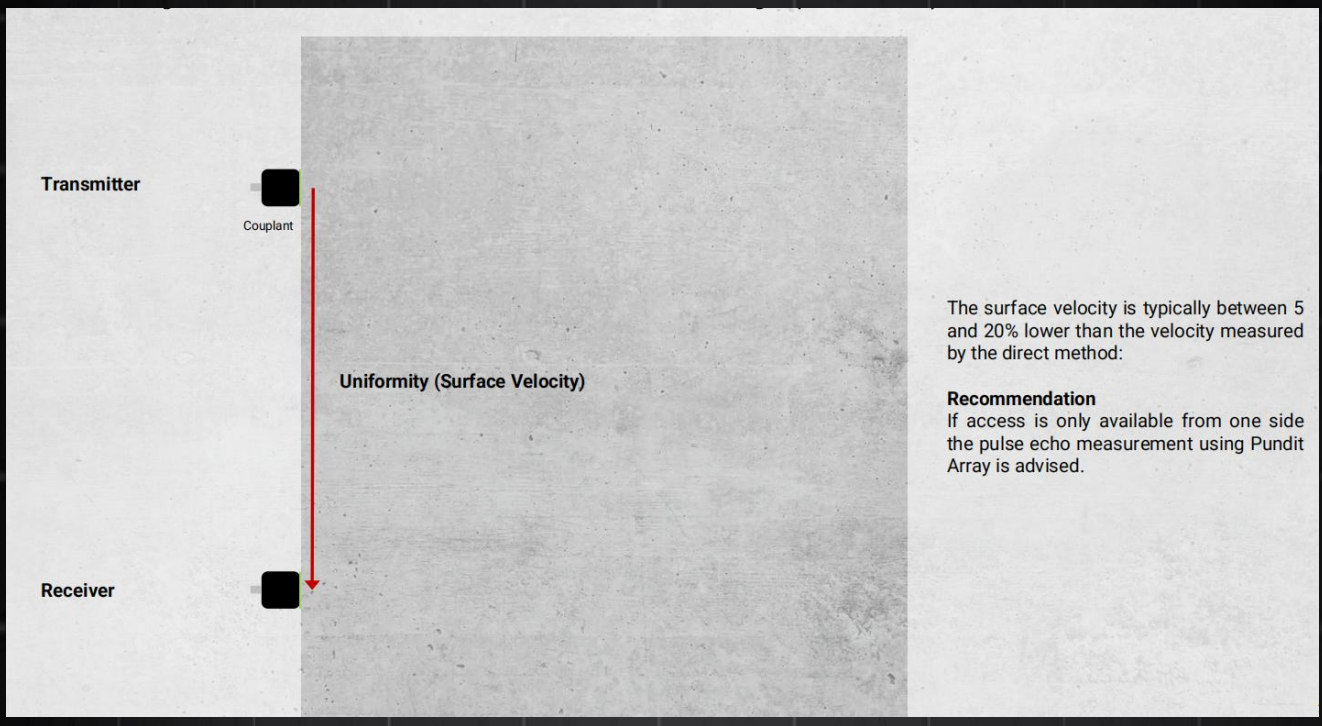
Physical principles

Homogeneity ► Ultrasound Pulse Velocity (Pundit)



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Physical principles

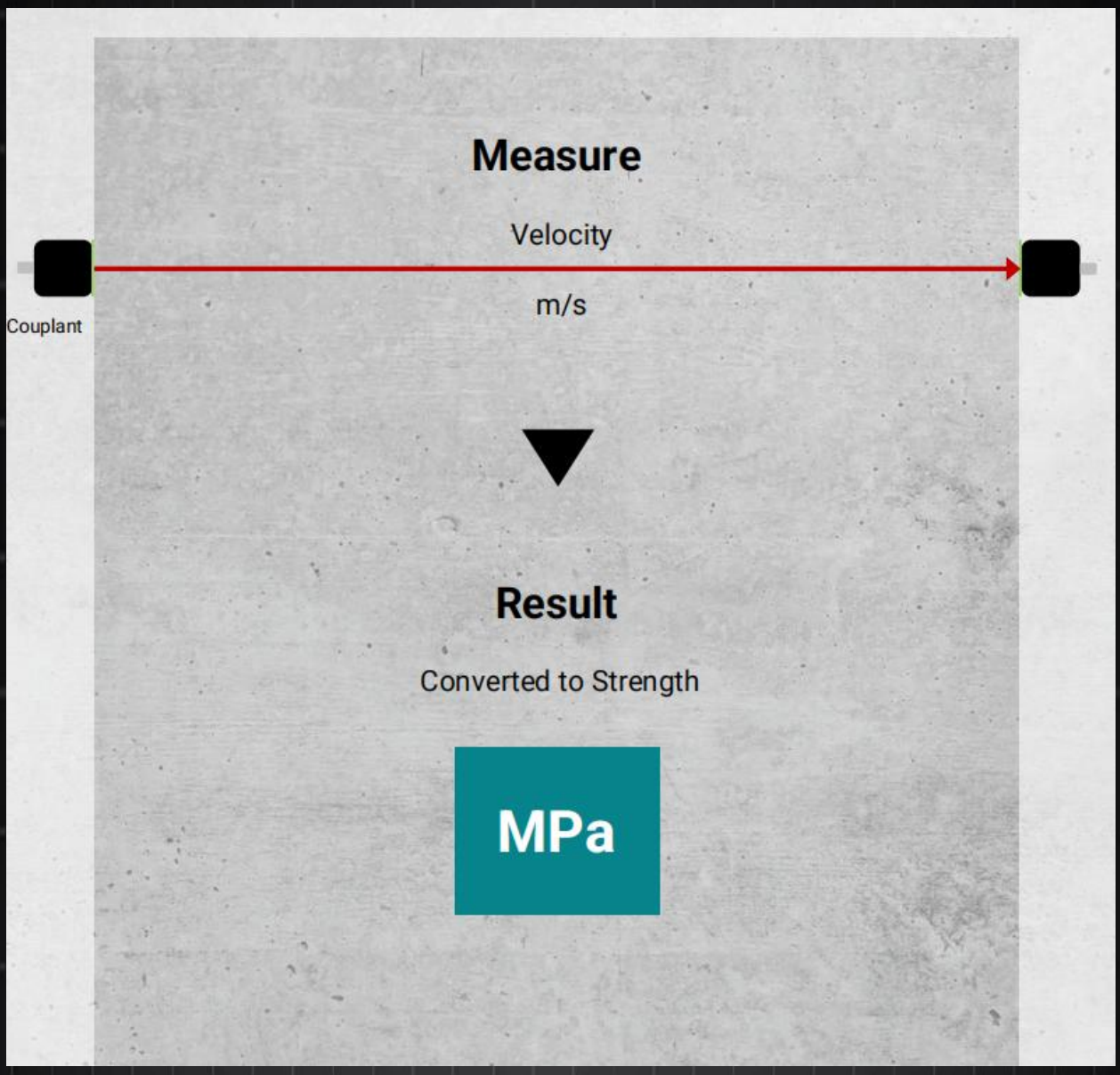


The surface velocity is typically between 5 and 20% lower than the velocity measured by the direct method:

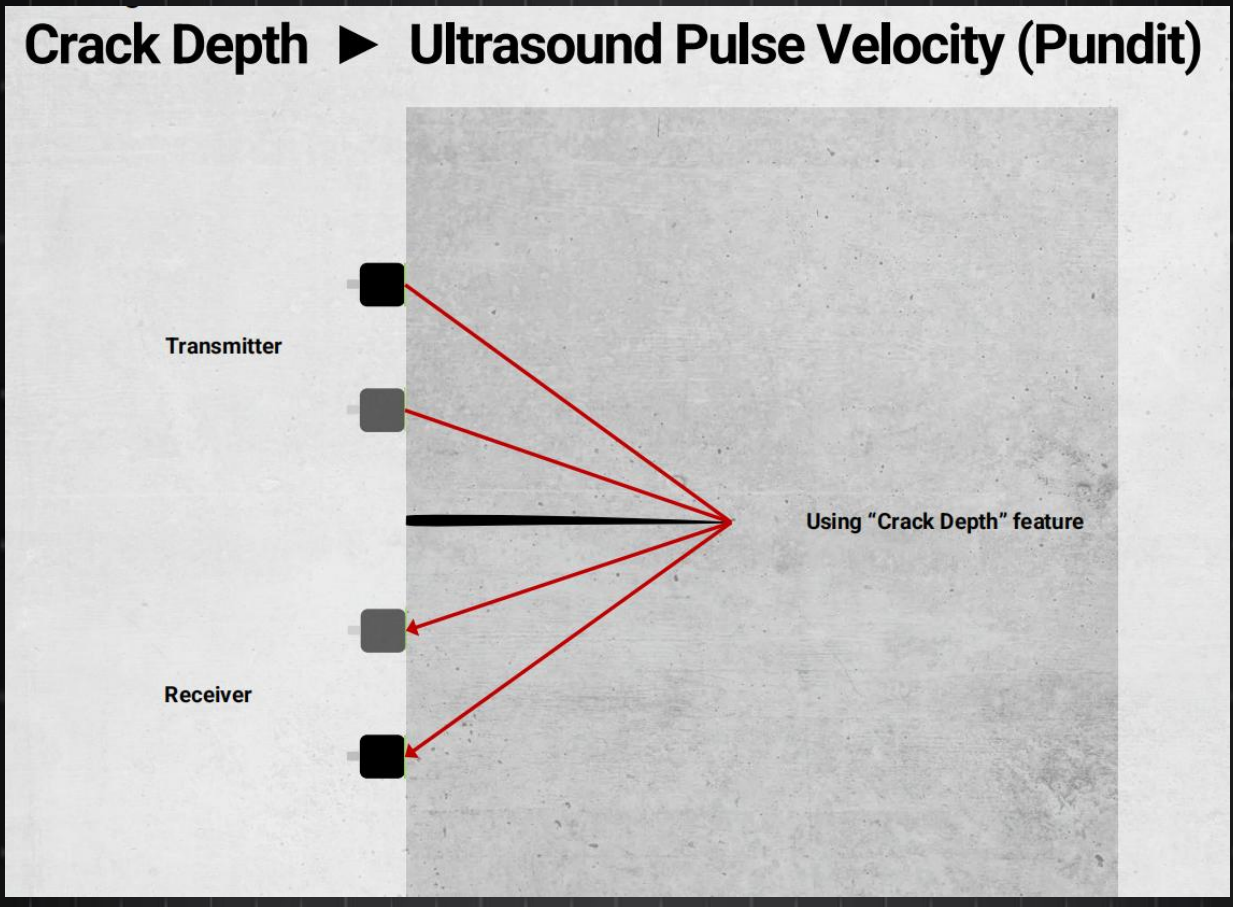
Recommendation
If access is only available from one side the pulse echo measurement using Pundit Array is advised.

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Physical principles

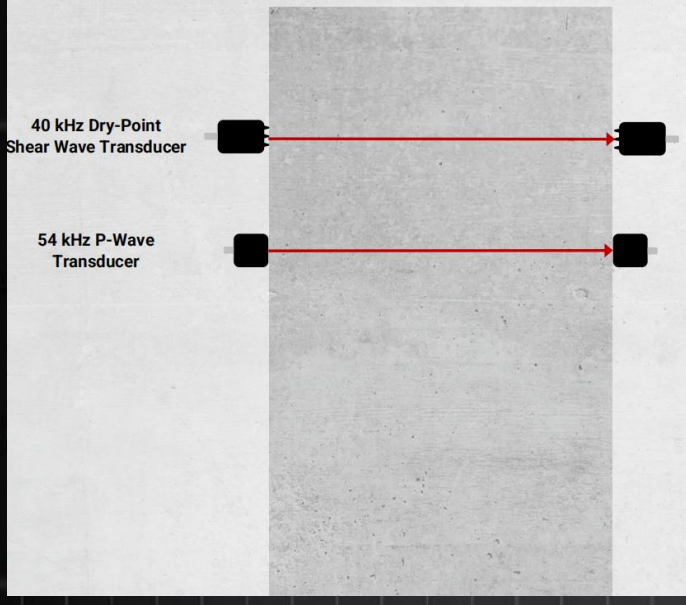


Physical principles



Physical principles

Dynamic Modulus of Elasticity ► Ultrasound Pulse Velocity (Pundit)



1. Measure shear wave velocity
2. Measure P-wave velocity
3. Input density
4. Calculate dynamic modulus of elasticity
5. Convert to static modulus of elasticity

Empirical relationship between static and dynamic modulus of elasticity and the pulse velocity		
Pulse velocity km/s	Modulus of Elasticity MN/m²	
	Dynamic	Static
3.6	24'000	13'000
3.8	26'000	15'000
4.0	29'000	18'000
4.2	32'000	22'000
4.4	36'000	27'000
4.6	42'000	34'000
4.8	49'000	43'000
5.0	58'000	52'000

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Physical principles

Important

1. Transducer selection	► **54 kHz** for Concrete Thickness 0.5 – 7 m ► **24 kHz** for mass concrete < 15m ► **40 kHz DPC** combine with P-wave measurements for elastic modulus ► **54 kHz Exponential** for rough or curved surfaces (possible use without couplant)
1. Measure over Rebar	► use Profometer to avoid measuring over rebars
2. Direct / Indirect measurement	► best results obtained with direct measurements ► indirect measurements provide no information about the interior of the concrete
3. Compressive strength testing	► **custom correlation curve** between destructive cylinder/cube test vs. pulse velocity ► SONREB combine with Schmidt measurements to improve strength estimations

Important

1. Transducer selection	► **40 kHz DPC Array** for Concrete Thickness 0.5 – 2 m
2. Measure over Rebar	► use Profometer to avoid measuring over rebars
3. Pulse echo measurement	► comparable with Pundit direct measurement
4. Compressive strength testing	► **S-wave correlation curve** between destructive cylinder/cube test vs. pulse velocity ► SONREB combine with Schmidt measurements to improve strength estimations

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Characteristics





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Characteristics

Channels

8 - 16

Modularity



Batteries

Wireless

Positioning + Detection

Weight

< 2.5 kg

pd

Line Scan
Heatmap
Time Slice
3D Tomography
Augmented Reality

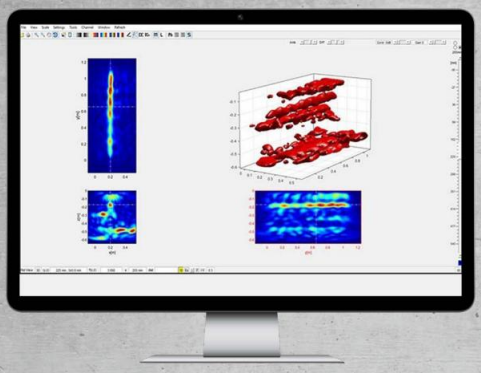
Penetration depth

> 2 m

- 30 %

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Post-processing (compared with GPR)



Pundit Vision

Outstanding visualization and analysis of ultrasonic pulse-echo data, empowering inspections with first of its kind capabilities

Expand your vision

Move through the 3D reconstructed image slice by slice, inspecting the areas of concern in intricate detail and accuracy

Combine your data

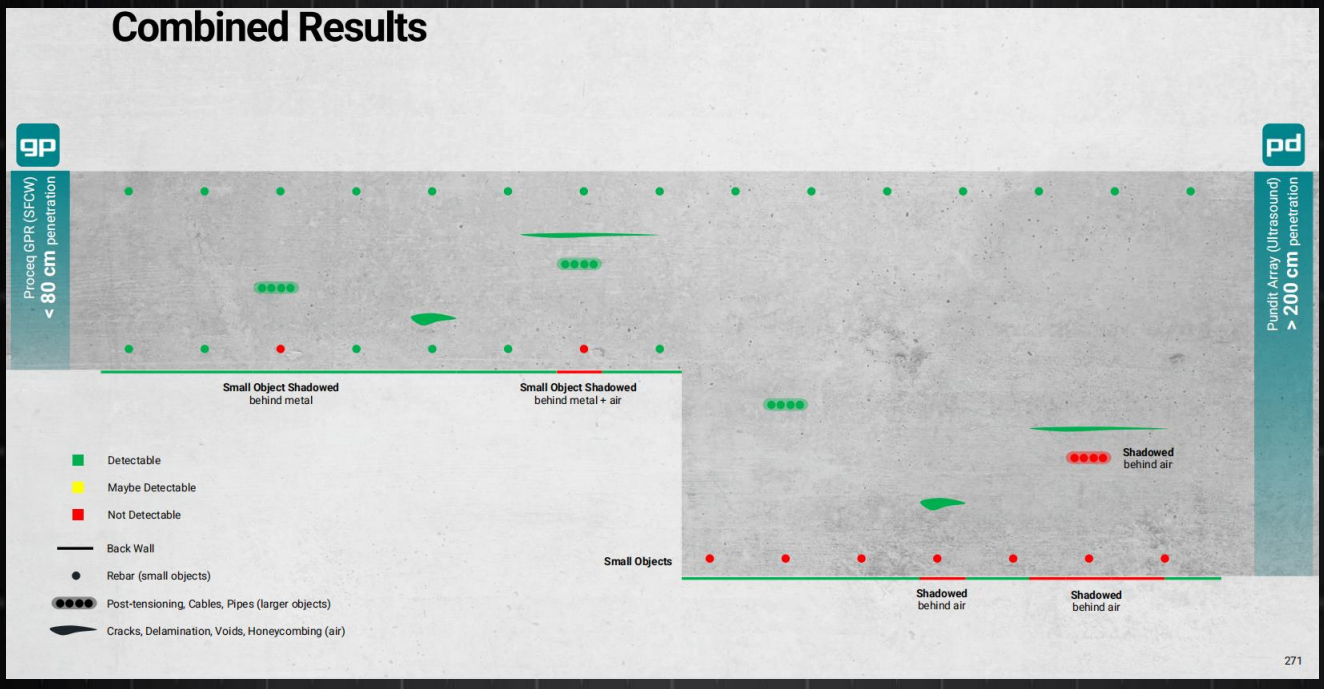
By combining your stripe scans or line scans you achieve a grand overview of the on-site inspection job you performed

☑ Performance ☑ Multifunctional ☑ Productivity

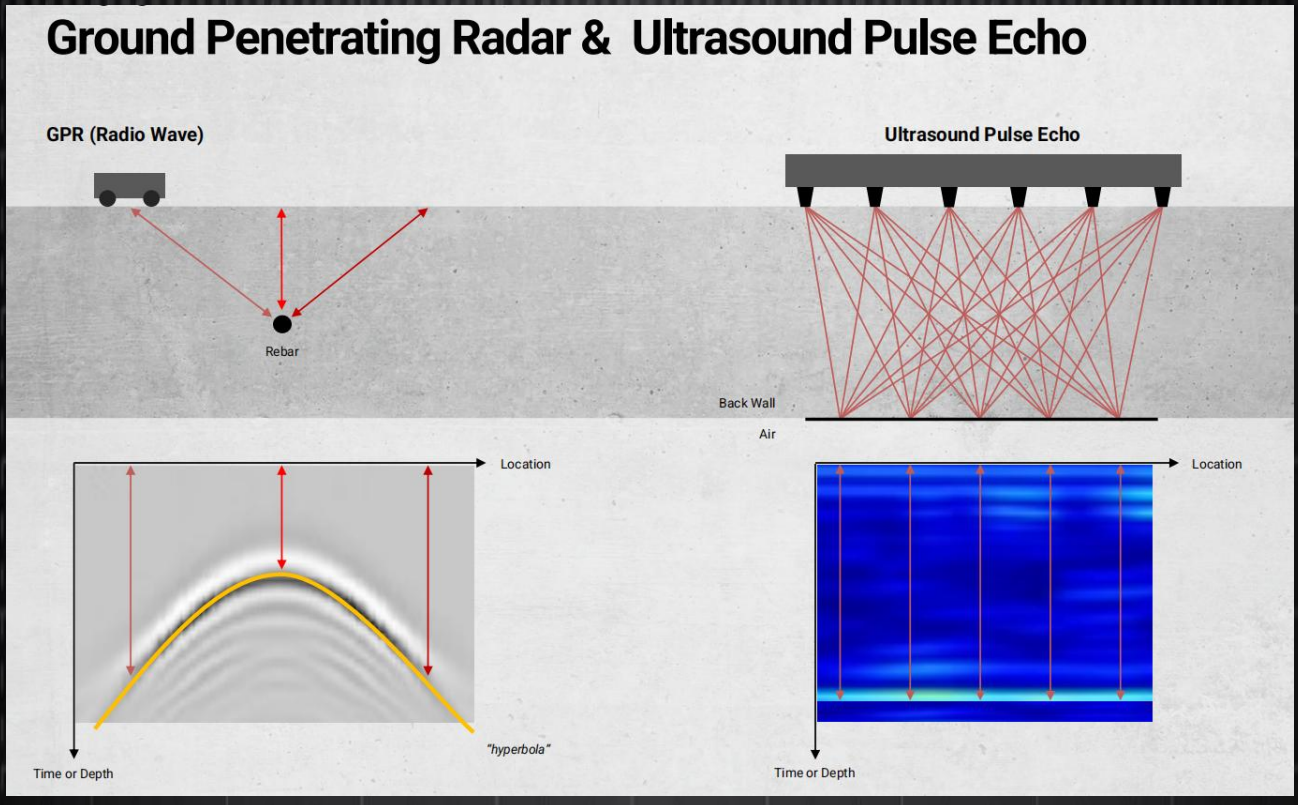


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Dectectability (compared with GPR)

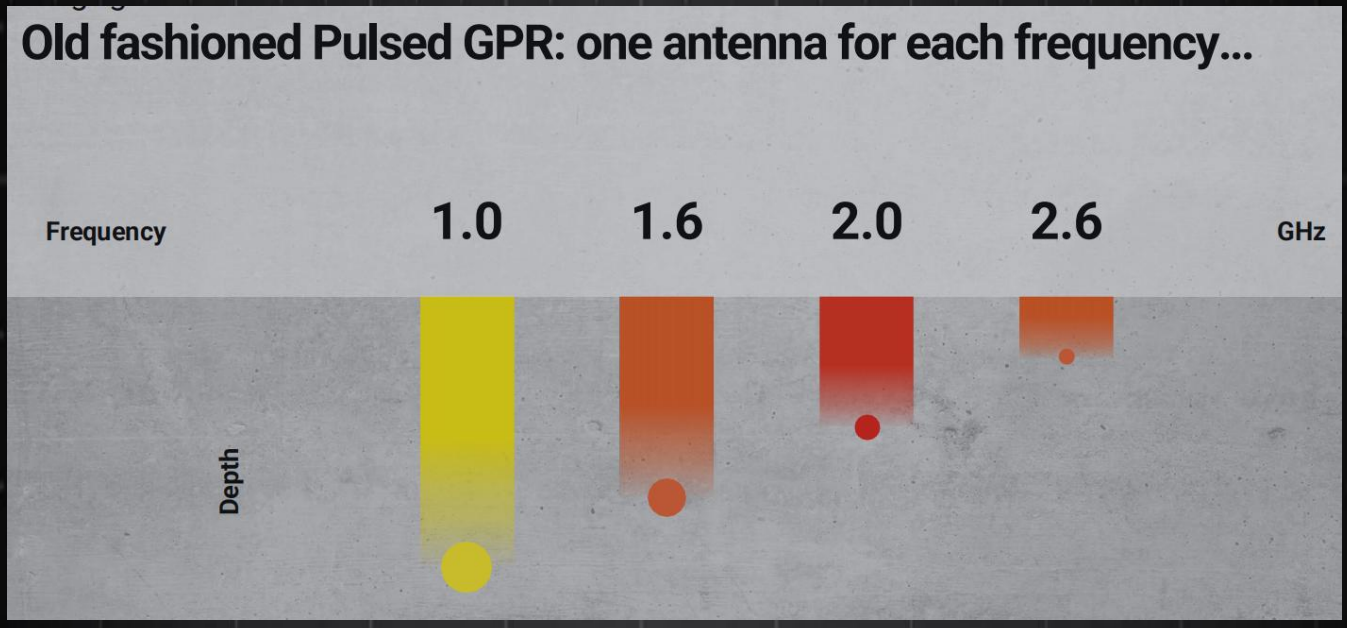


Comparison with GPR

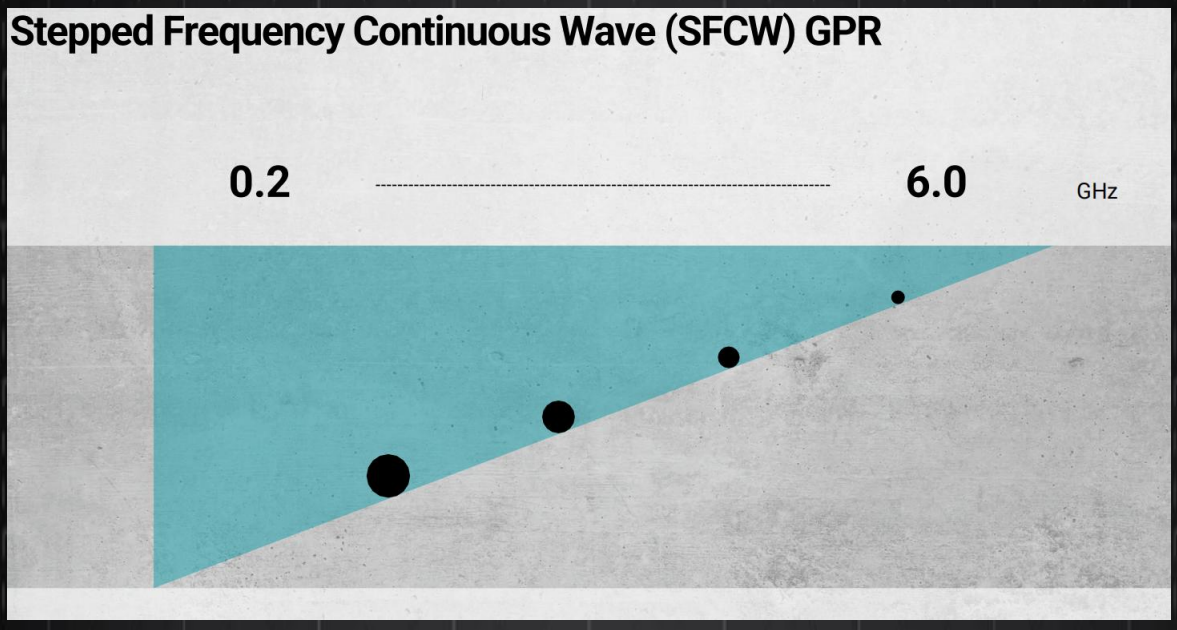


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Comparison with GPR

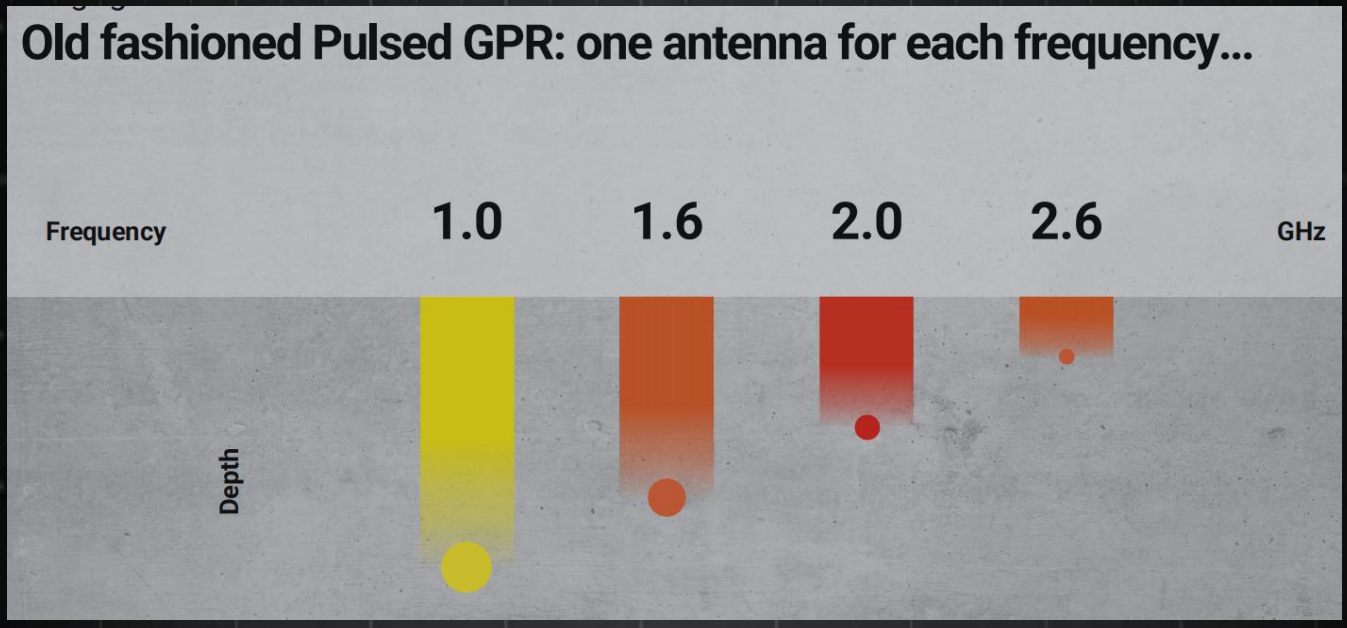


Comparison with GPR



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Comparison with GPR



Comparison with GPR

Reflection

GPR				Ultrasonic Pulse Echo			
Interface	ε_1	ε_2	R	Interface	Z_1	Z_2	R
Concrete - Metal	7	∞	100%	Concrete - Metal	9.6	46.5	43%
Concrete - Air	7	1	45%	Concrete - Air	9.6	.000429	99%

$$R = \frac{\sqrt{\varepsilon_1} - \sqrt{\varepsilon_2}}{\sqrt{\varepsilon_1} + \sqrt{\varepsilon_2}}$$

R = energy reflected
ε_1 = permittivity of concrete
ε_2 = permittivity of 2nd material

$$R = \frac{(z_2 - z_1)^2}{(z_2 + z_1)^2}$$

R = energy reflected
Z_1 = acoustic impedance concrete
Z_2 = acoustic impedance 2nd material

Ground Penetrating Radar (GPR) & Ultrasound Pulse Echo

GPR

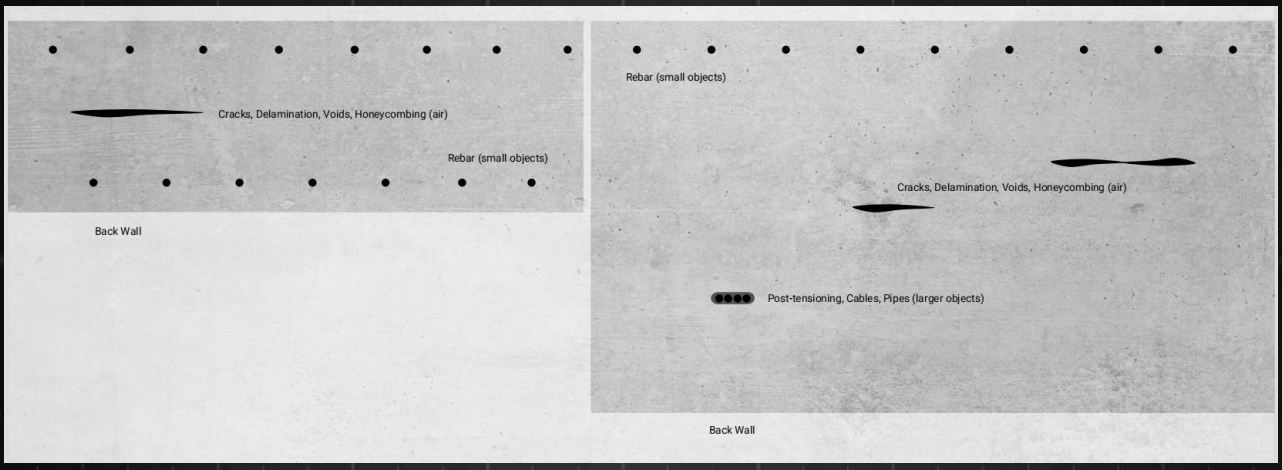
- **100%** reflection of **metal objects**
- **cannot see** objects **behind metal**
- travels (55%) **through air gaps**
- **45%** reflection of **larger air gap**
- can **see** objects **behind an air gap**

Ultrasonic Pulse Echo

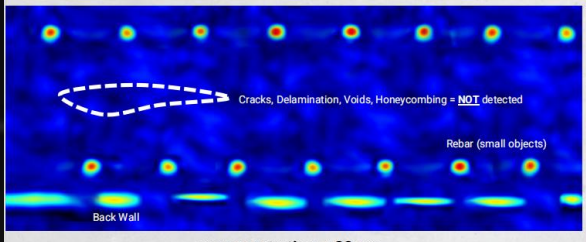
- **99%** reflection of **air gaps**
- **cannot** see objects **behind air gaps**
- travels (57%) **through metal objects**
- **43%** reflection of **larger metal objects**
- can **see** other objects **behind metal objects**

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Comparison with GPR

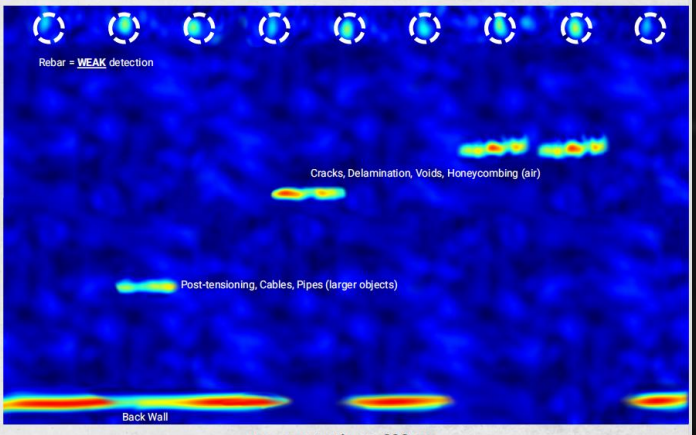


Ground Penetrating Radar (GPR)



max penetration < 80 cm

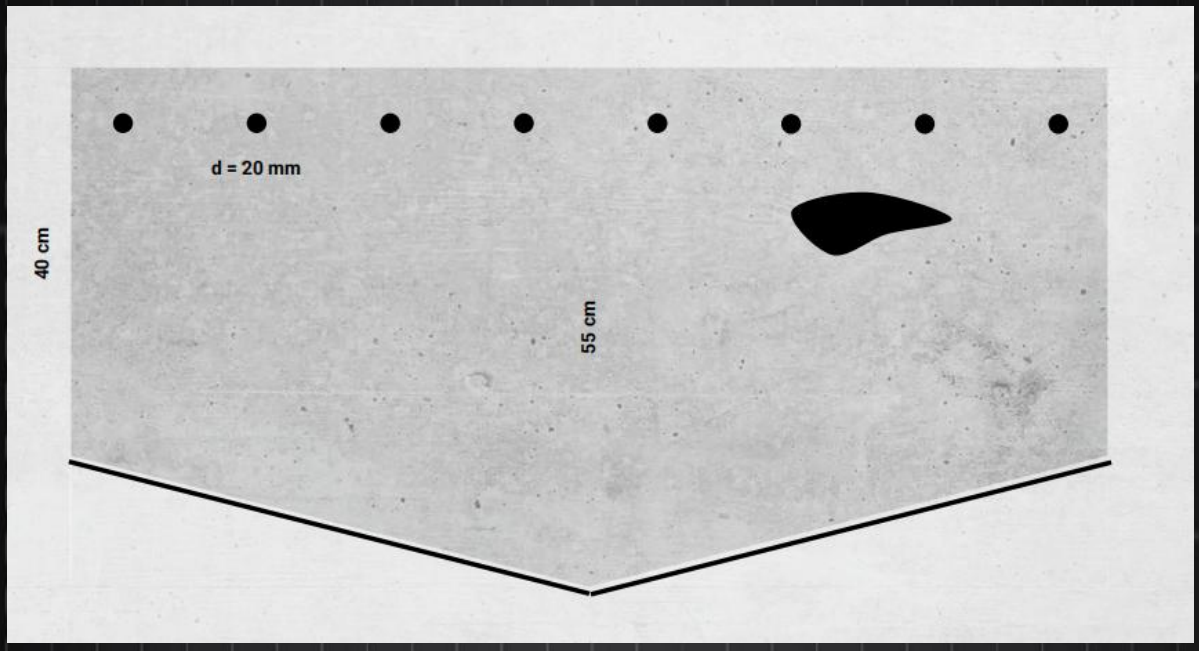
Ultrasound Pulse Echo



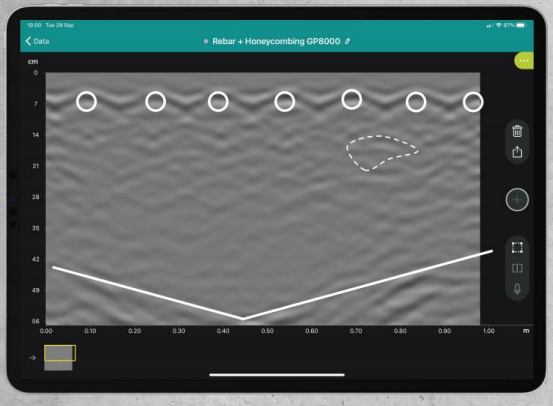
max penetration ≥ 200 cm

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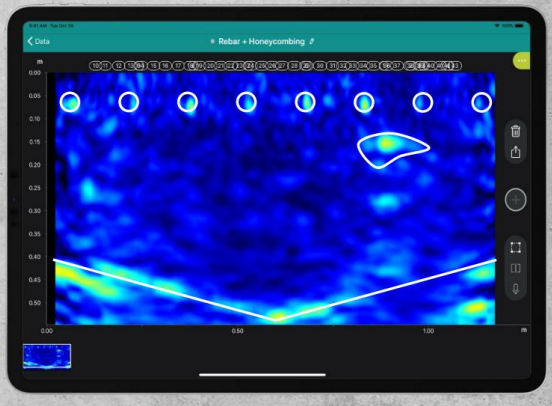
Comparison with GPR



Ground Penetrating Radar (Proceq GPR)

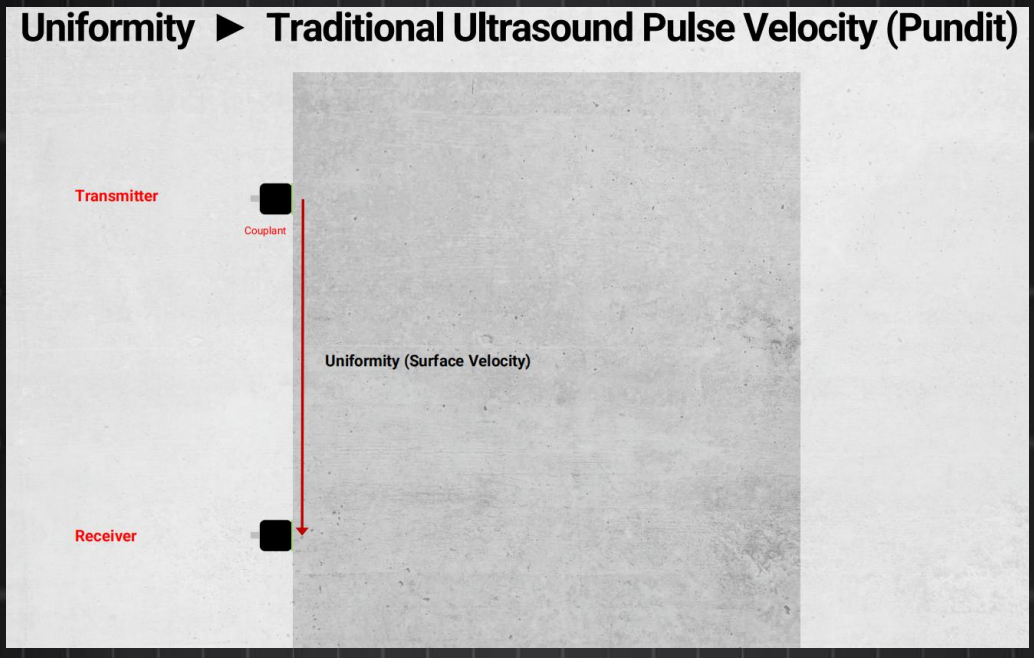


Ultrasound Pulse Echo (Pundit Array)



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Comparison between the Traditional Ultrasound Pulse Velocity (Pundit) and Ultrasound Pulse Velocity (Pundit Array)





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