دانشگاه صنعتی شدیف

گروه مهندسی خوردگی و حفاظت از مواد

خوردگی سازه های بتنی

ابوالقاسم دولتی

استاد دانشگاه

• تخریب بتن

فرآیندهای تخریب بتن را می‌توان بصورت زیر طبقه‌بندی کرد:

۱- فیزیکی (به علت تغییرات حرارتی طبیعی مثل چرخه های انجماد – آب شدن یا تغییرات حرارتی مصنوعی)،

۲- مکانیکی (سایش، فرسایش، ضربه، انفجار)،

۳- شیمیایی (حمله یون کلرید، اسیدها، سولفاتها، یون‌های آمونیوم و منیزیم، آب خالص، واکنش‌های قلیایی اجزای بتن)،

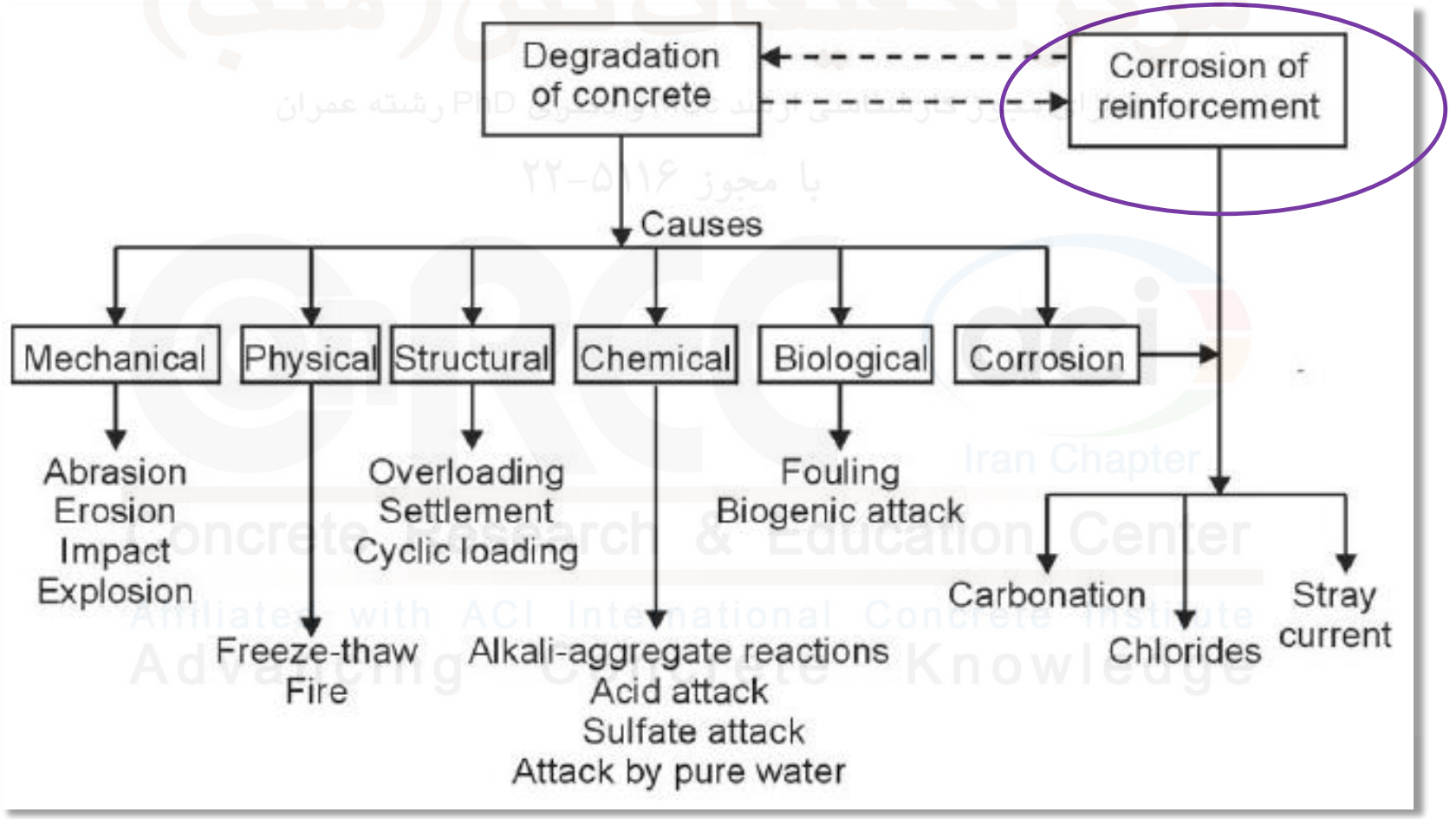
۴- بیولوژیکی (فولینگ، تهاجم بیوژنیک)

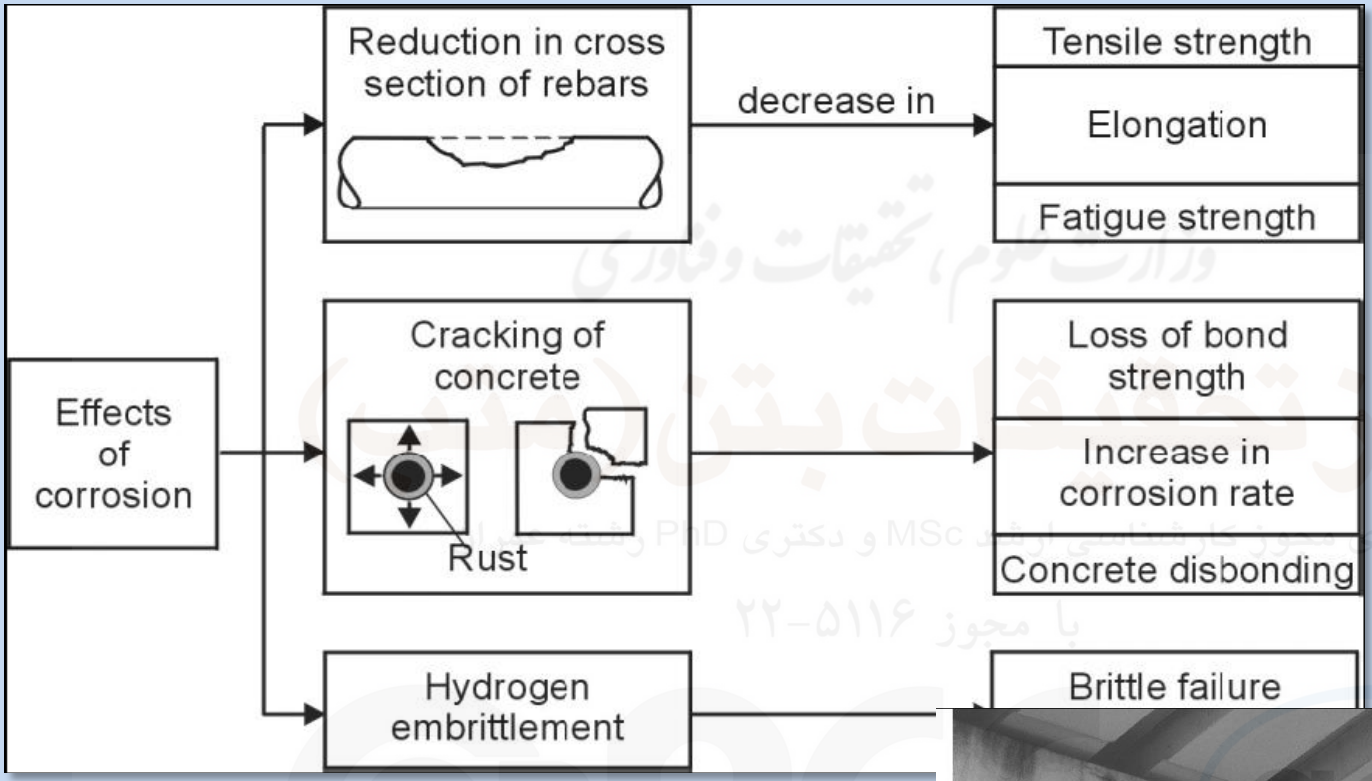
۵- سازه ای (بارگذاری بیش از حد، نشست ساختمان، بارگذاری چرخه‌ای).

۶- خوردگی آرماتور (کربناسیون، کلریدی، جریان سرگردان)

- **تخریب بتن**

۶- خوردگی آرماتور(کربناسیون، کلریدی، جریان سرگردان)





پیامد خوردگی آرماتور در بتن مسلح

*مکانیزم خوردگی فولاد در بتن

فاکتورهای موثر بر خوردگی بتن

الف: ترکیب سیمان

ب: مقدار سیمان در متر مکعب

ج: ترکیب بتن (طرح اختلاط)

د: تراکم بتن

ه: شرایط عمل آوردن

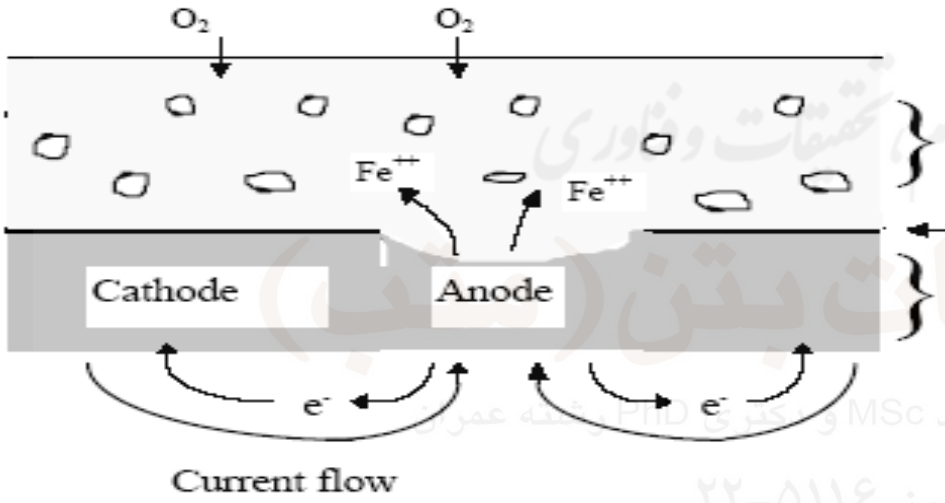
و: شرایط محیطی بتن

$$Fe \rightarrow Fe^{+2} + 2e^{-}$$

$$\frac{1}{2}O_2 + H_2O + 2e^{-} \rightarrow 2OH^{-}$$

Cathode Process
$O_2 + 2\,H_2O + 4\,e^- \rightarrow 4\,OH^-$

Anode Process
$Fe \rightarrow Fe^{2+} + 2e^-$

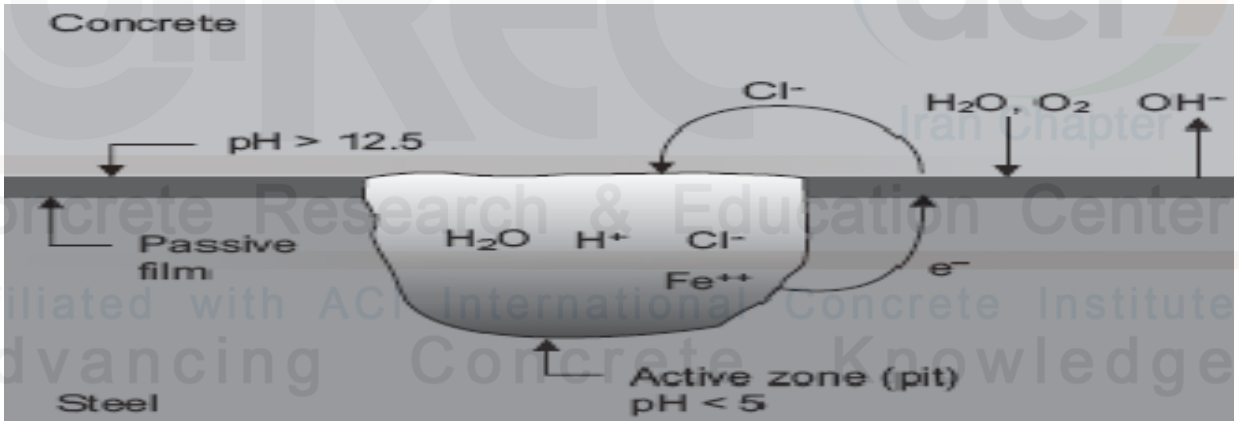


$$Fe \rightarrow Fe^{+2} + 2e^-$$

$$\frac{1}{2}O_2 + H_2O + 2e^- \rightarrow 2OH^-$$

مکانیزم خوردگی فولاد در بتن

$$Fe^{+2} + 2Cl^- \rightarrow FeCl2$$



شمایی از خوردگی موضعی به واسطه ورود یون کلر

پارامترهای مؤثر در خوردگی فولاد در بتن

- **فاکتورهای درونی**

۱)ترکیب سیمان

۲)ناخالصی ها در شن

۳)ناخالصیها در مخلوط آب عمل آوری

۴)افزودنی ها

۵)نسبت w/c

۶)مقدار سیمان

۷)اندازه شن و دانه بندی

۹)ضخامت پوشش روی آرماتور

۱۰)ترکیب شیمیای و ساختمان آرماتور

۱۱)تخلخل

- **فاکتورهای خارجی**

۱)دسترسی به اکسیژن

۲)رطوبت

۳)نفوذ آب

۴)کربناسیون و ورود ترکیبات اسیدی به سطح میلگرد

۵)آنیون های مهاجم

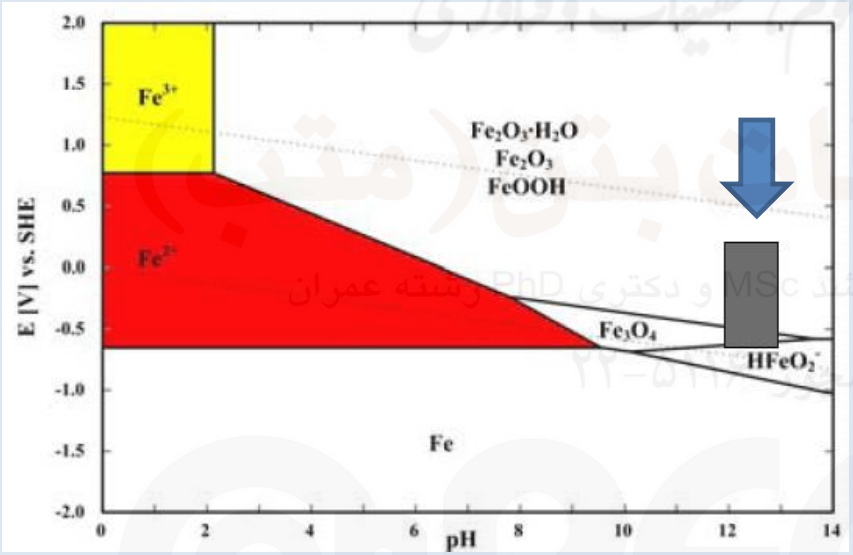
۷)خوردگی بیولوژی و عملکرد باکتریها

۸)حملات اسیدی

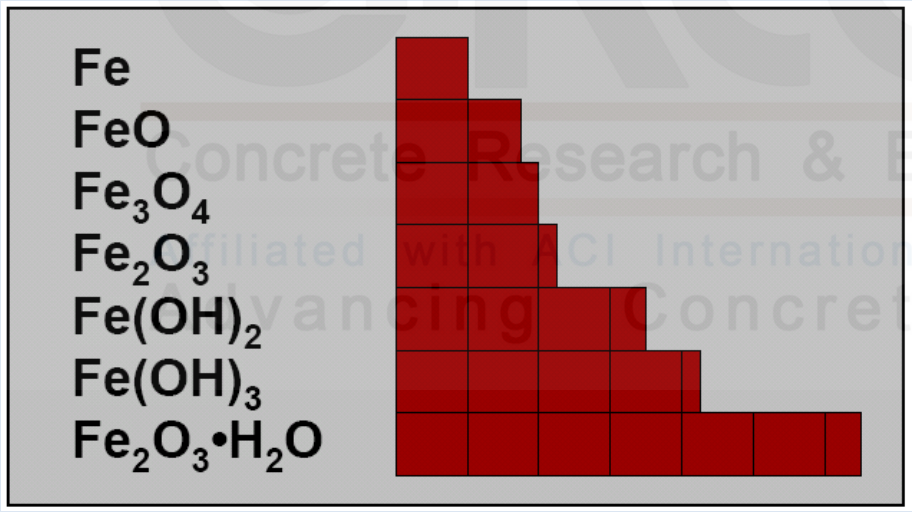
۹)دما

۱۰)جریان های سرگردان

خوردگی بتن



- بتن ذاتاً بدلیل قلیائیت بالا از خوردگی آرماتور محافظت می کند



- در صورت وقوع خوردگی، محصولات خوردگی دارای حجم بالاتری از فولاد دارد (۸ تا ۱۲ برابر)

انواع خوردگی شیمیای در بتن

- خوردگي سولفات ها
- خوردگي توسط دي اكسيد كربن
- اثر توأم كربناسيون وحملات سولفاتي
- واكنش قلیایي سنگدانه ها
- حملات كلرايدي
- اثر اندركنش سولفات و كلرايد
- اثر كربناسيون در بتن حاوي كلر
- تخريب ناشي از خوردگي فولاد در بتن

خوردگی سولفات ها

- سولفات ها عمدتاً در آبهای زیرزمینی،آب دریا، خاکها و غیره حضور دارند
- هنگامی که یونهای سولفات محلول وارد منافذ بتن می شوند، با آهک آزاد موجود در آن واکنش داده و ژیپس تولید می شود

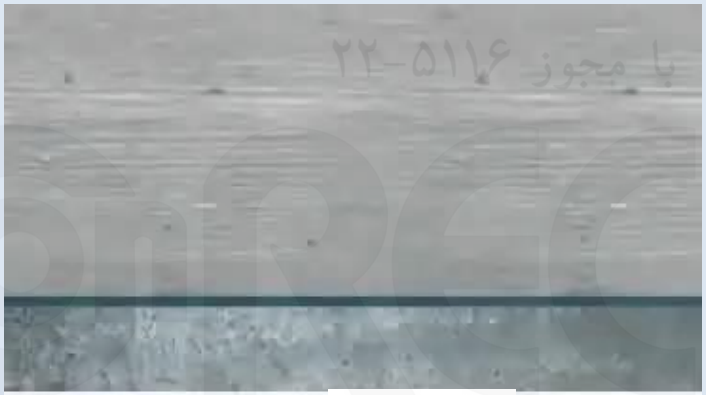
$$Ca^{+2} + SO_4^{-2} + 2H_2O \rightarrow CaSO_4.2H_2O$$

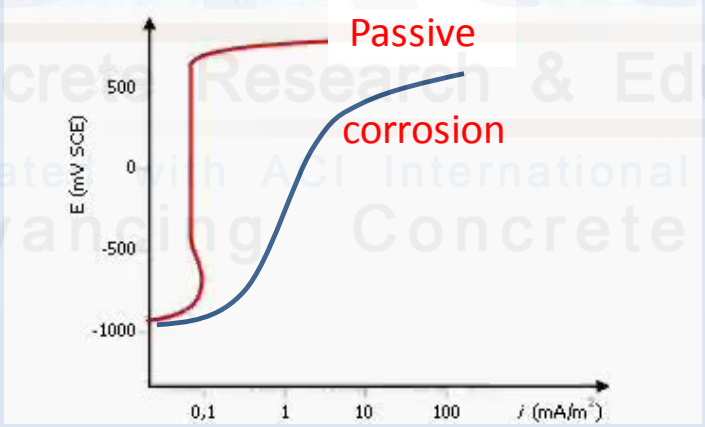
- محصول گچ (ژیپس) تولید شده باعث سستی سطح بتن و کاهش مقاومت و سبب ۱۲۴ درصد افزایش حجم مواد جامد می شود.
- حمله سولفاتی سولفات منیزیم آب دریا به مراتب شدیدتر از سایر سولفات ها می باشدکه علاوه بر انبساط، سبب نرم شدن بتن به دلیل تجزیه ترکیبات هیدراسیون سیلیکات های کلسیم در بتن (C-H-S) می شود.

خوردگی توسط دی اکسید کربن

- دی اکسید کربن موجود در هوا به داخل بتن نفوذ کرده، هیدروکسید کلسیم به کربنات کلسیم تبدیل می شود ودر نتیجه میزان pH کاهش می یابد

$$C-S-H+CO_2+H_2O \Leftrightarrow CaCO_3+SiO_2(gel)+H_2O$$





حملات کلرایدی

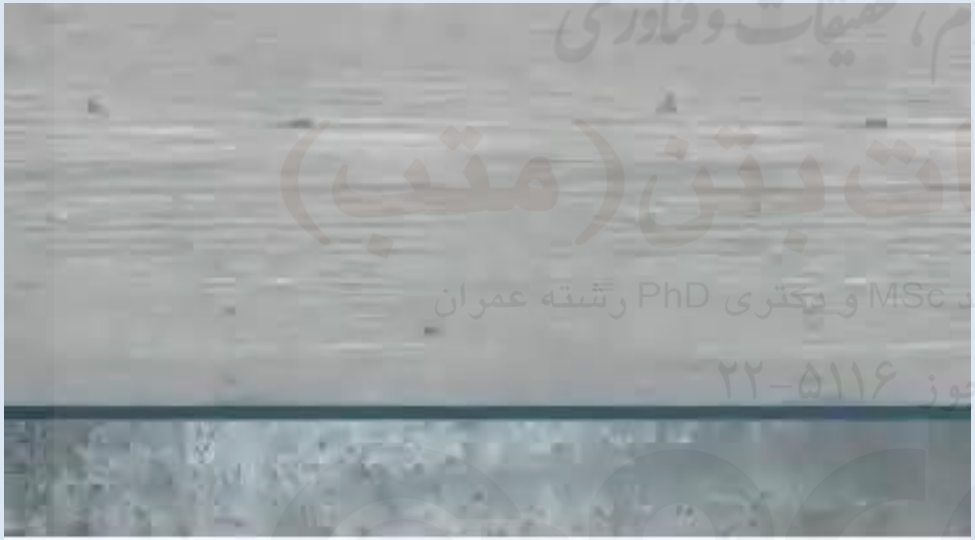
- کلراید بدو صورت می تواند وارد بتن شود

(الف) همراه ترکیبات بتن که آلوده به کلر باشند.

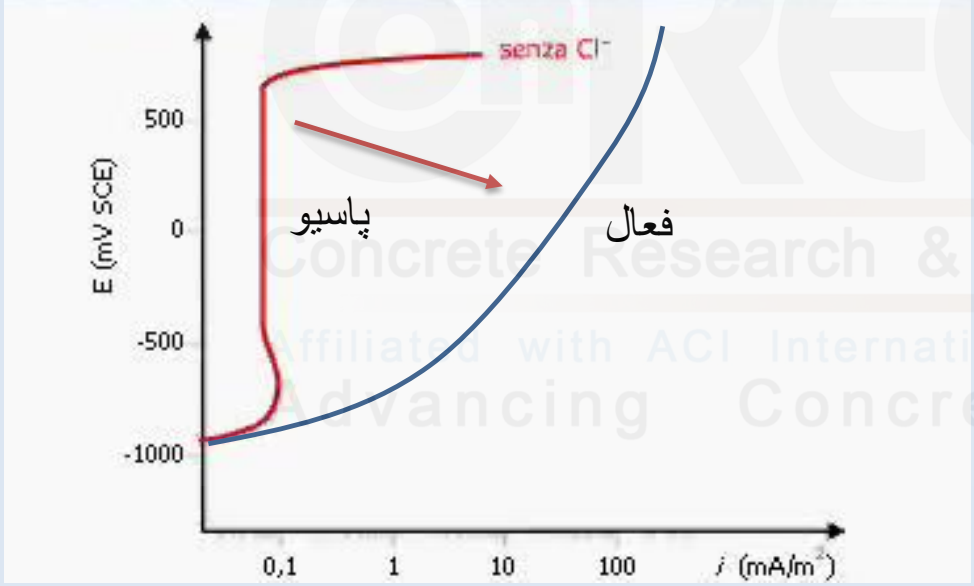
(ب) نفوذ کلر از محیط خارجی پیرامون بتن از منابعی مانند نمک های ضد یخ، آب دریا.

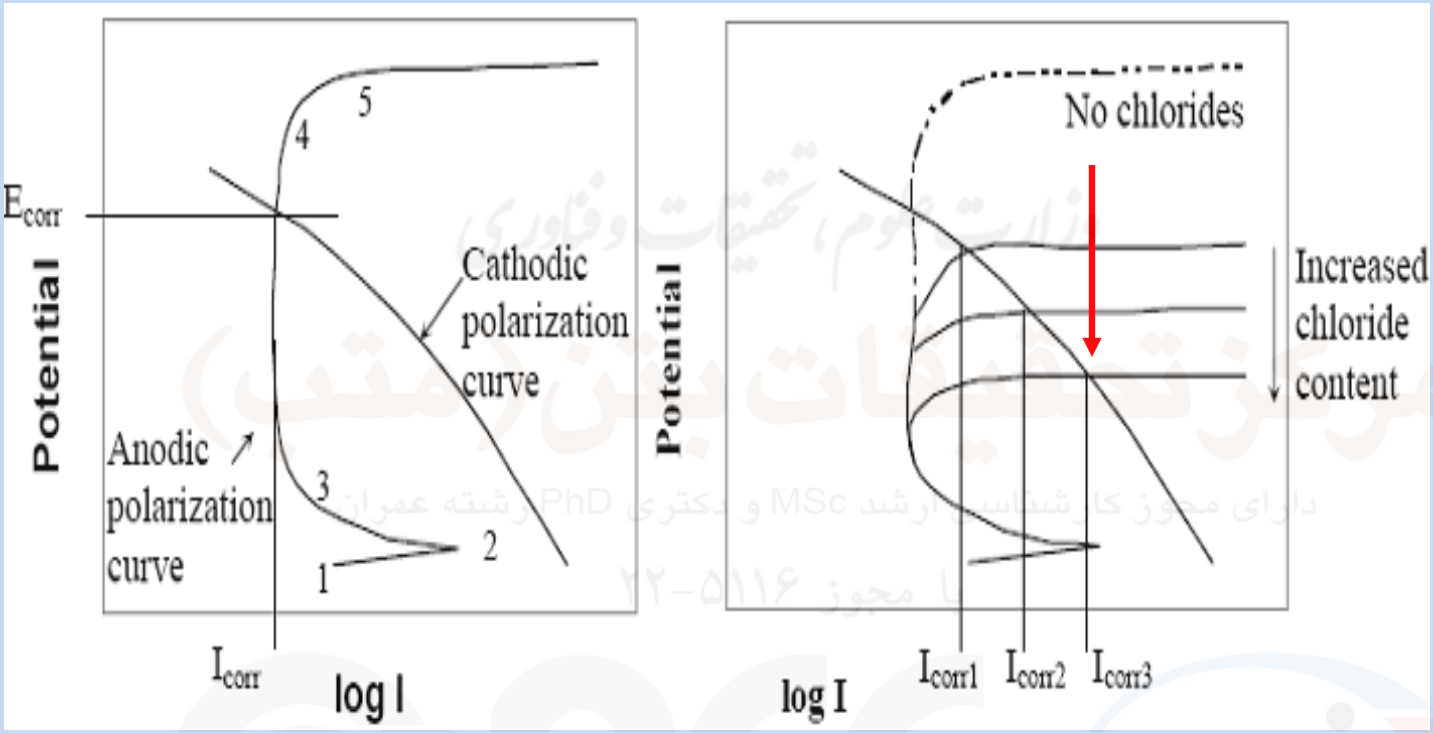
- معمولاً کلرایدی که به سطح آرماتور می رسد باعث شکست لایه پسیو می شود
- وجود سولفات و کلراید در خمیر سیمان باعث می شود که غلظت یون در محلول منافذ افزایش یابد
- فعالیت خوردگی فولاد در محلول سولفات (همراه هیدروکسید کلسیم) به میزان ۷ برابر بیشتر از زمانی است که فولاد فقط در معرض محلول کلرایدی است .

حملات کلرایدی

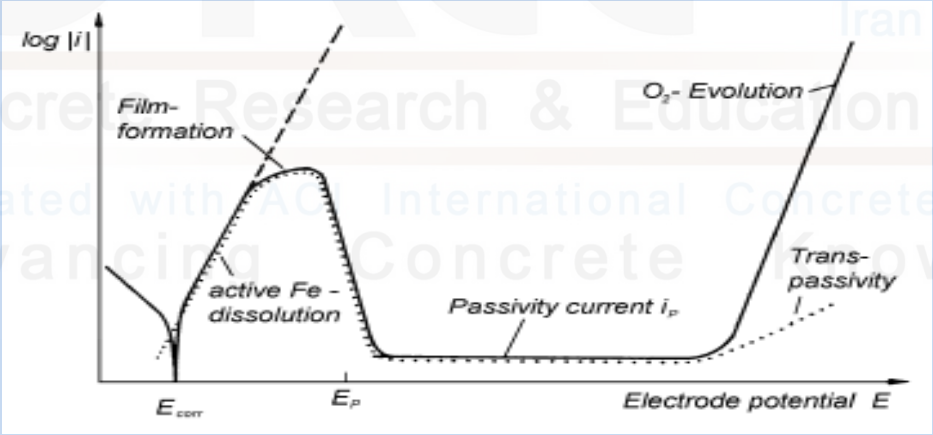


خوردگی بصورت حفرات تا سطح





اثر یون کلر بر شاخه آندی منحنی پلاربزاسیون فولاد در بتن و کاهش طول ناحیه پسیو



روش های ارزیابی خوردگی:

۱- روش اندازه گیری پتانسیل

- تفسیر اندازه‌گیری های پتانسیل خوردگی [۴۰]

تفسیر	Ag/AgCl	کالومل SCE	$Cu/CuSO_4$
احتمال بیش از ۹۰٪ بدون خوردگی	$E\rangle -119mV$	$E\rangle -126mV$	$E\rangle -200mV$
وضعیت خوردگی نامشخص است	$-119\langle E\langle -269mV$	$-126\langle E\langle -276mV$	$-200mv\langle E\langle -350mV$
بیش از ۹۰٪ احتمال خوردگی است	$E\langle -269mV$	$E\langle -276mV$	$E\langle -350mV$

روش های ارزیابی خوردگی:

۲- روش اندازه گیری مقاومت ویژه بتن:

ریسک خوردگی بر اساس مقاومت ویژه

Resistivity (Ohm.cm.)	Corrosion risk
Greater than 20,000	Negligible
10,000 to 20,000	Low
5,000 to 10,000	High
Less than 5,000	Very high

۳- روش اندازه گیری جریان خوردگی:

- تفسیر وضعیت های خوردگی نسبت به جریان خوردگی[۴۶]

Corrosion current (I_{corr})	Condition of the rebar
$I_{corr} < 0.1\ \mu A/cm^2$	Passive condition
I_{corr} 0.1 - 0.5 $\mu A/cm^2$	Low to moderate corrosion
I_{corr} 0.5 - 1.0 $\mu A/cm^2$	Moderate to high corrosion
$I_{corr} > 1.0\ \mu A/cm^2$	High corrosion rate
The device without sensor control has the following recommended interpretation.	
$I_{corr} < 0.2\ \mu A/cm^2$	No corrosion expected
I_{corr} 0.2 - 1.0 $\mu A/cm^2$	Corrosion possible in 10 -15years
I_{corr} 1.0 - 10 $\mu A/cm^2$	Corrosion expected in 2-10years
$I_{corr} > 10\ \mu A/cm^2$	Corrosion expected in 2 years or less

خوردگی آرماتور در محیط دریایی

خوردگی آرماتور در محیط دریایی

روند تخریب بتن

نمونه ای از صدمات ناشی از نفوذ کلراید+کربناسیون

Figure 1. Seaview Wharf

Figure 2. Typical corrosion damage

* روشهای حفاظت از خوردگی سازه های بتنی:

۱– حفاظت کاتدی: آند فدا شونده – سیستم اعمال جریان

۲– ممانعت کننده در سطح آرماتور ممانعت کننده فولاد (ممانعت کننده متداول – ممانعت کننده هوشمند)

۳– ممانعت کننده در ترکیب اختلاط ممانعت کننده بالک بتن – اگزالات پتاسیم

۳– ممانعت کننده های نافذ ترکیبات نفوذ کننده از سطح بتن تا آرماتور

۴– ملات آب گریز در سطح لایه ملات آب گریز با ترکیبات متیل سیلانی

۵– ترکیبات آب بند در بتن ذرات سیلیس آب گریز و میکروسیلیس

۶– محلول های آب گریز نافذ در بتن ترکیبات سیلان سیلوکسان با قابلیت جذب در بتن و واکنش در بتن

۷– رنگ و پوشش های سطحی پوشش های رنگ اپوکسی و پلی یورتان و پلی یوریا و پوشش های پلیمری

* تخریب شیمیایی سازه های بتنی:

–تخریب سازه های بتنی، ناشی از نفوذ رطوبت و یون کلر یکی از عمده ترین دلایل تخریب شیمیایی بتن به شمار می آید.

– استفاده از مواد افزودنی مناسب به عنوان جایگزین بخشی از سیمان پرتلند در سازه های بتنی موجب افزایش مقاومت به خوردگی و دوام سازه های بتنی می گردد.

- **اثر افزودن میکروسیلیس، سرباره کوره بلند و الیاف پلی پروپیلن به بتن**
- **افزودنی میکروسیلیس ۲–۱۰٪ سیمان**
- **سرباره کوره ی بلند بر روی مقاومت به خوردگی آرماتور فولادی، طرح اختلاط های حاوی ۱۰ – ۲۰ ٪ سیمان**
- **الیاف پلی پروپیلن با اندازه های ۶، ۱۲ و ۱۹ میلی متر با نسبت ۰.۵، ۱ ، ۱.۵، ۲ درصد حجمی بتن**

* روش ارزیابی رفتار خوردگی:

–جهت بررسی مقاومت به خوردگی بتن از:

۱- آزمون های پتانسیل مدار باز،

۲-مقاومت الکتریکی ویژه بتن،

۳ - تست نفوذ پذیری بتن

٤-اندازه گیری میزان جذب آب،

٥-درصد تخلخل بتن،

٦-پتانسیل خوردگی آرماتور،

۸-رفتار پلاریزاسیون i-E ،

۹-طیف سنجی امپدانس الکتروشیمیایی

۱۰-استحکام فشاری بتن

A: Concrete specimens

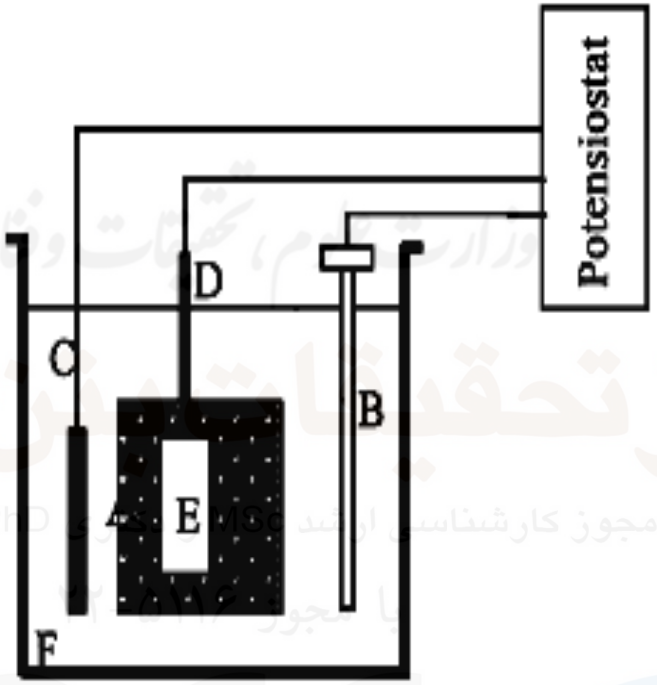
B: Calomel reference electrode

C: Counter Electrode

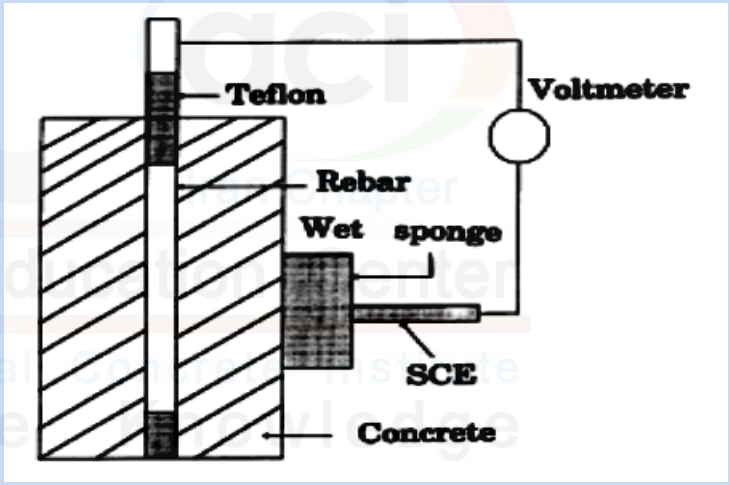
D: Epoxy coating and isolation

E: Ø10 Steel bar

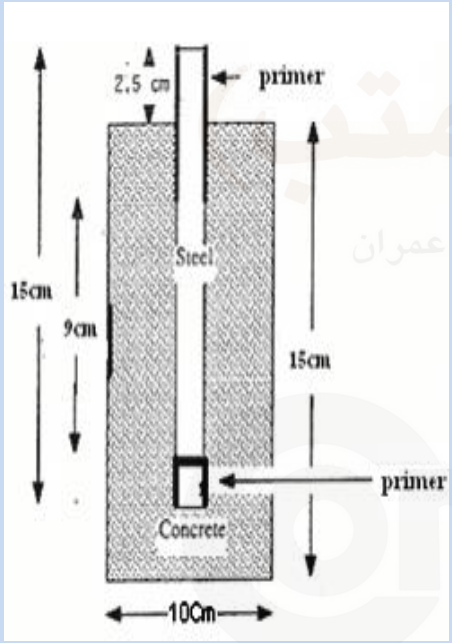
F: NaCl solution



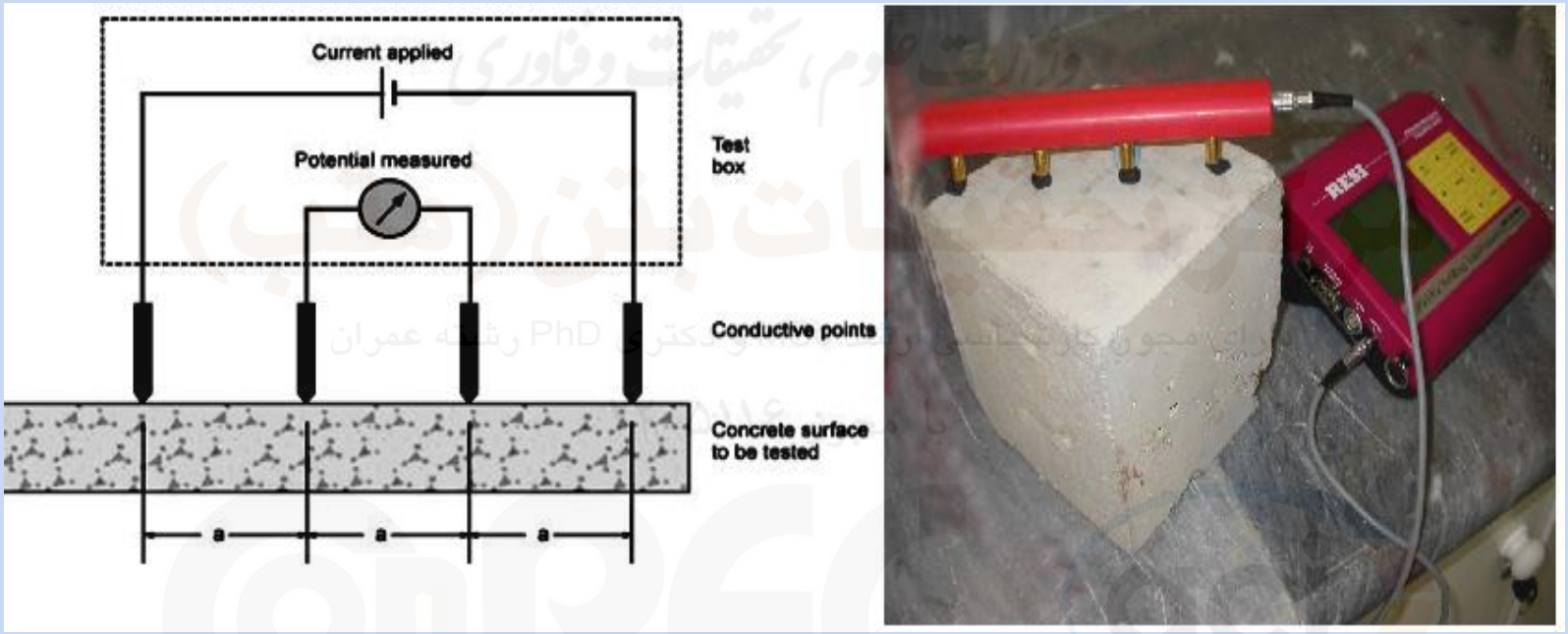
شمایی از بررسی رفتارخوردگی توسط پلاریزاسیون



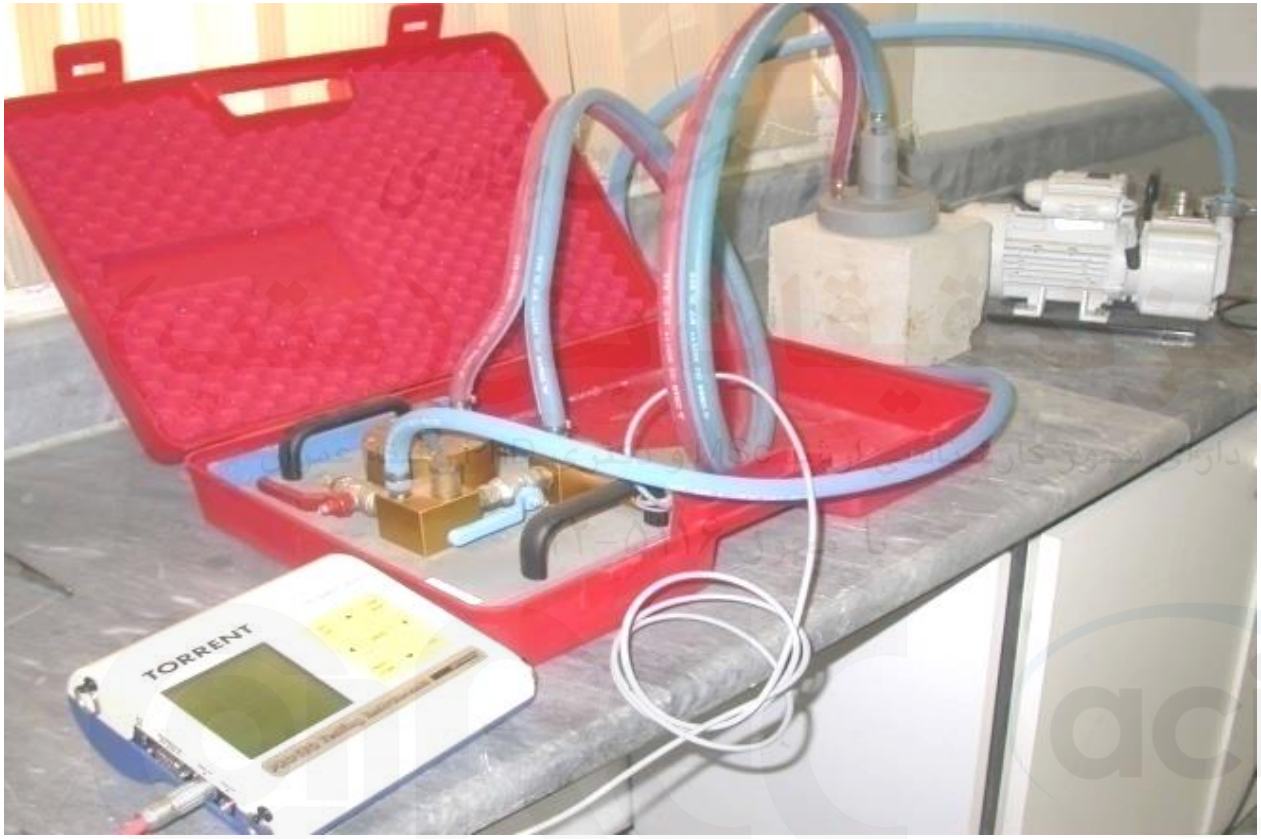
نمایی از اندازه گیری پتانسیل میلگرد فولادی در بتن.



ابعاد نمونه بتنی استوانه ای شکل.



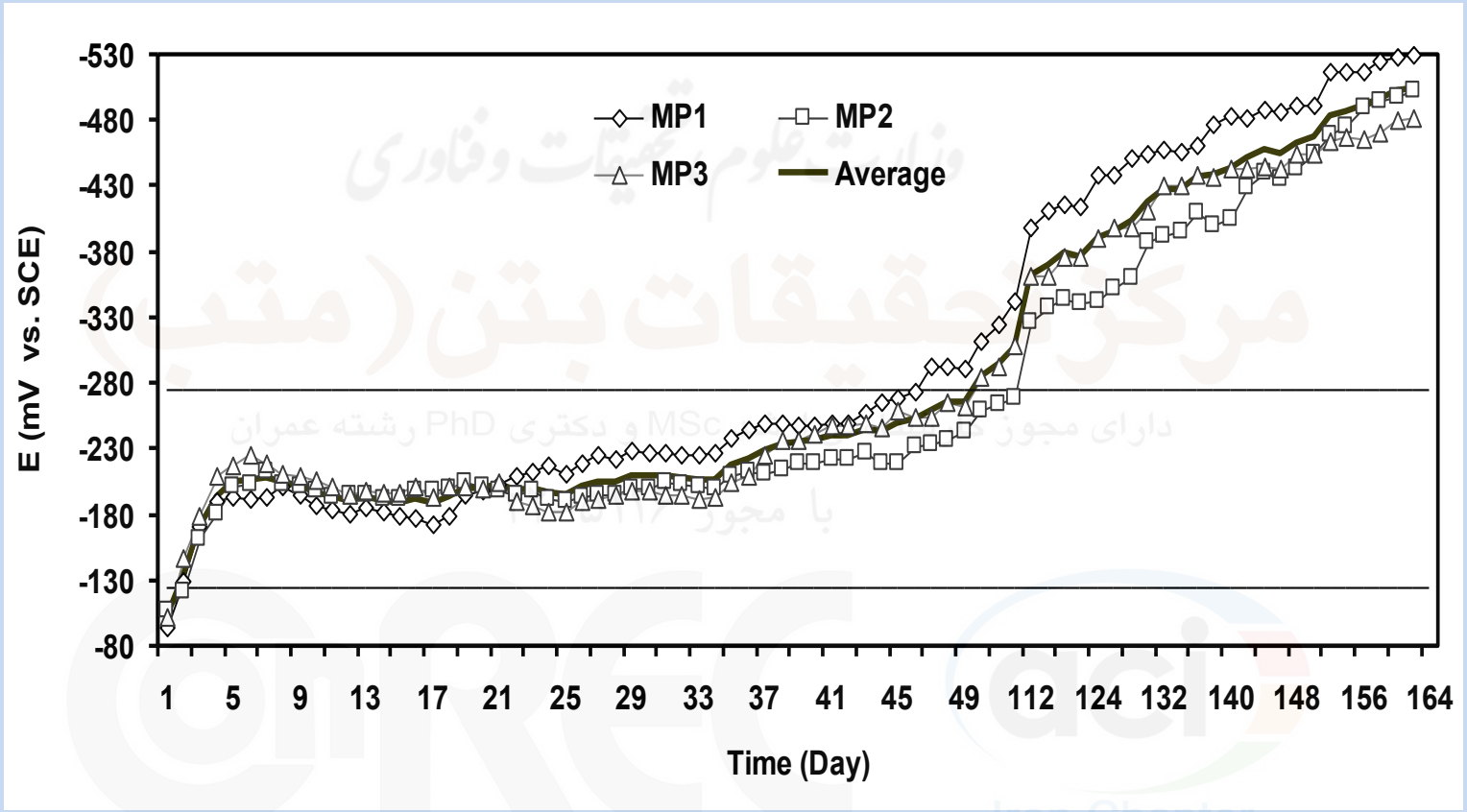
اندازه گیری مقاومت الکتریکی بتن به روش چهار پینه ونر



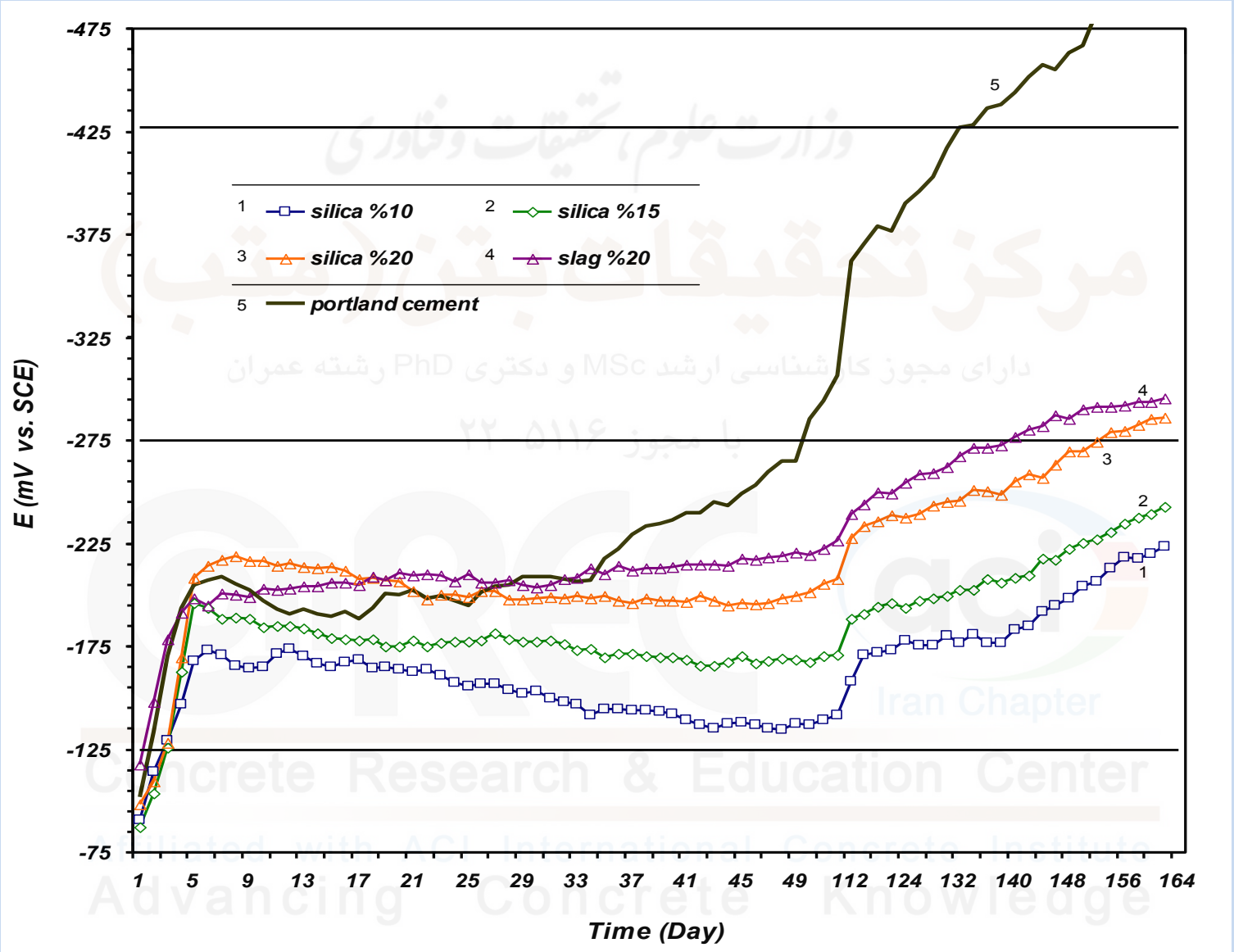
دامنه نفوذپذیری ذاتی

اندازه گیری آزمون نفوذ پذیری ذاتی

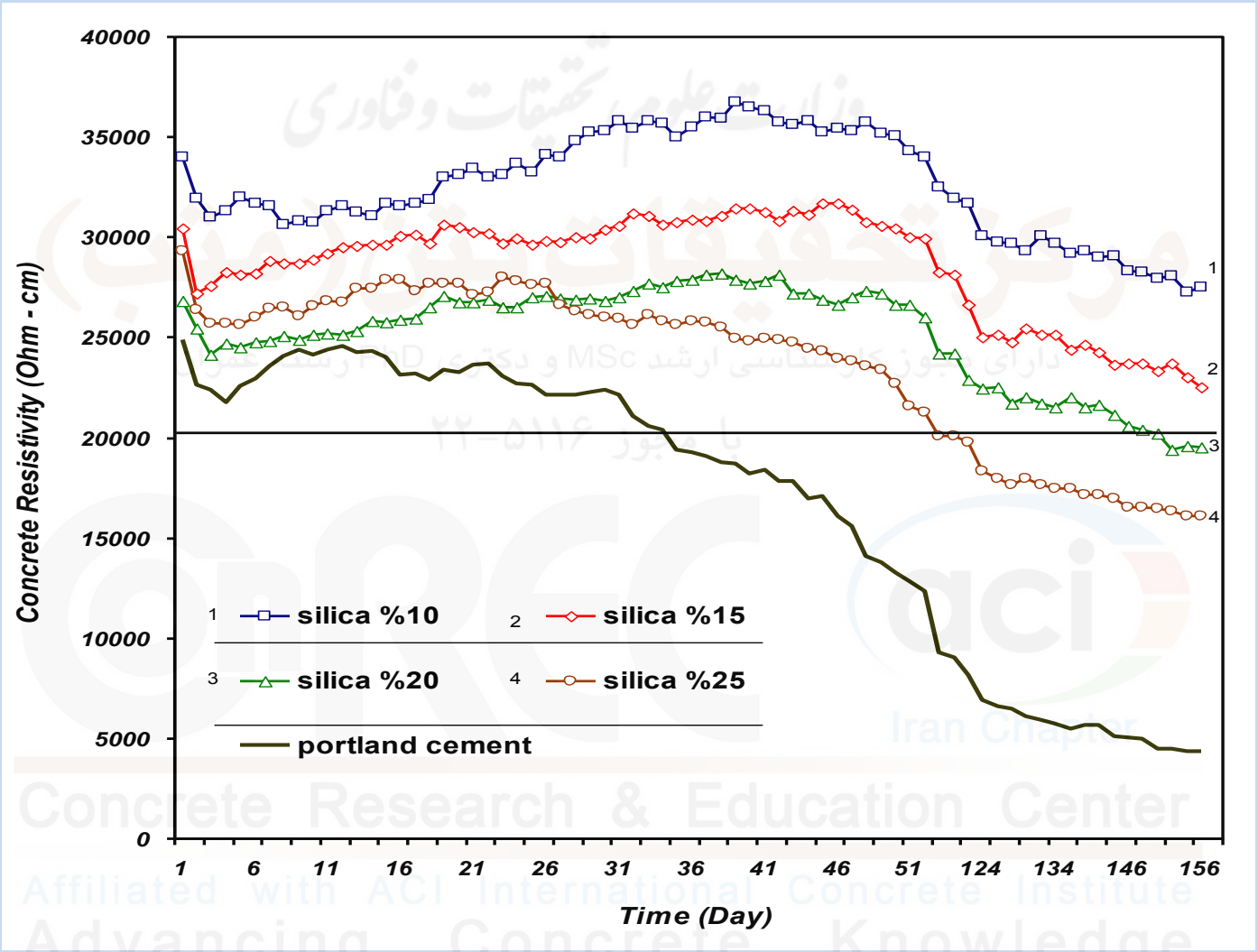
نوع آزمایش	واحد	کم	متوسط	زیاد
نفوذپذيري ذاتي	m^2	$< 10^{-19}$	$10^{-19} - 10^{-17}$	$> 10^{-17}$



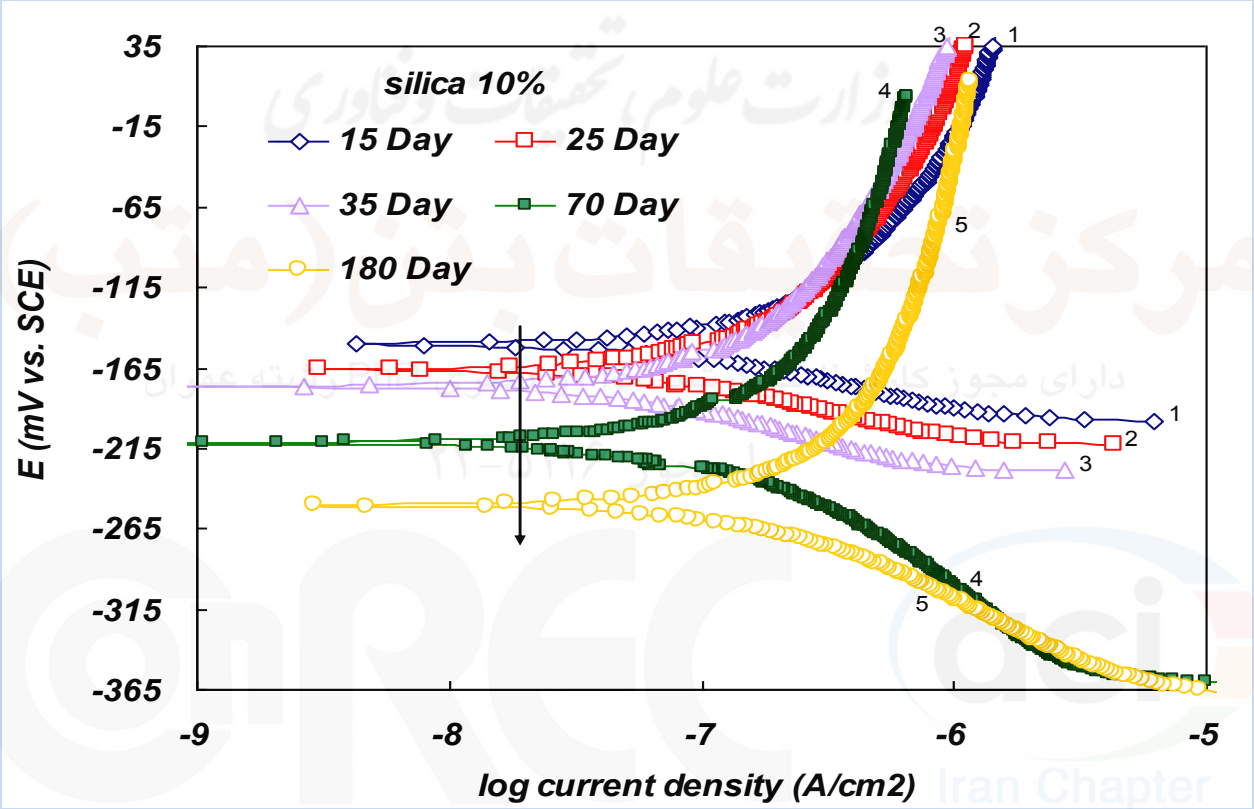
شکل ۳-۱- تغییرات پتانسیل نسبت به زمان برای مخلوط بتنی با سیمان پرتلند نوع دو در محلول ۳/۵٪ NaCl.



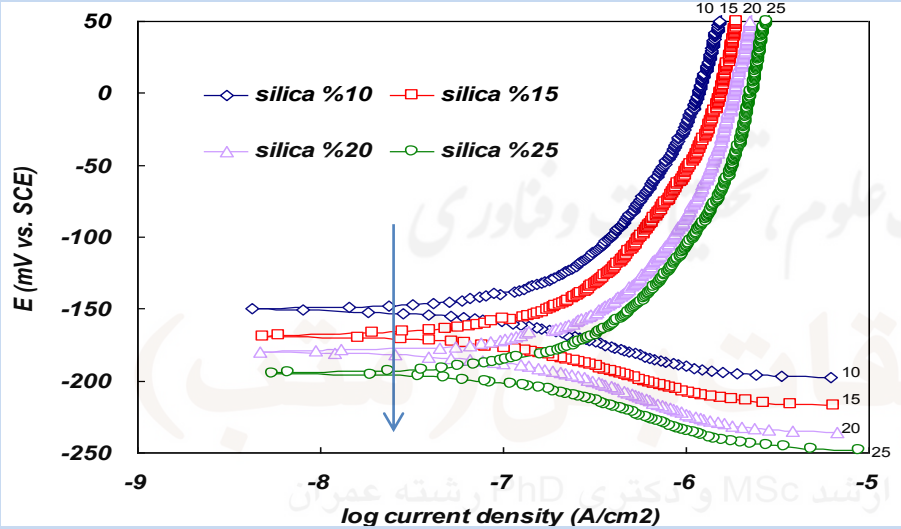
شکل۳- ۶- مقایسه تغییرات پتانسیل نسبت به زمان برای نمونه های بتنی با افزودنی پودر سیلس در محلول ۳/۵٪ کلرید سدیم



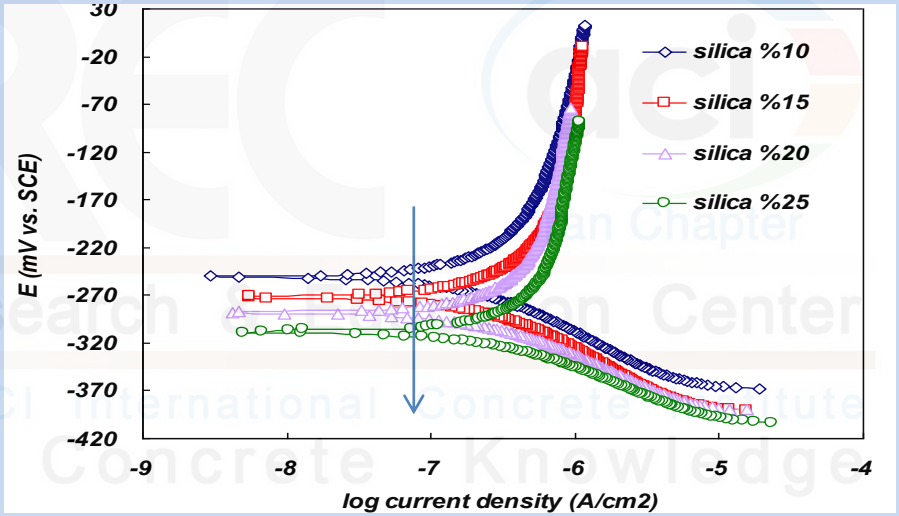
شکل۳- ۷- تغییرات مقاومت الکتریکی مخلوطهای بتن با درصدهای ۱۰ و ۱۵ و۲۰ و ۲۵ پودر سیلیس در محلول ۳/۵٪ کلرید سدیم.



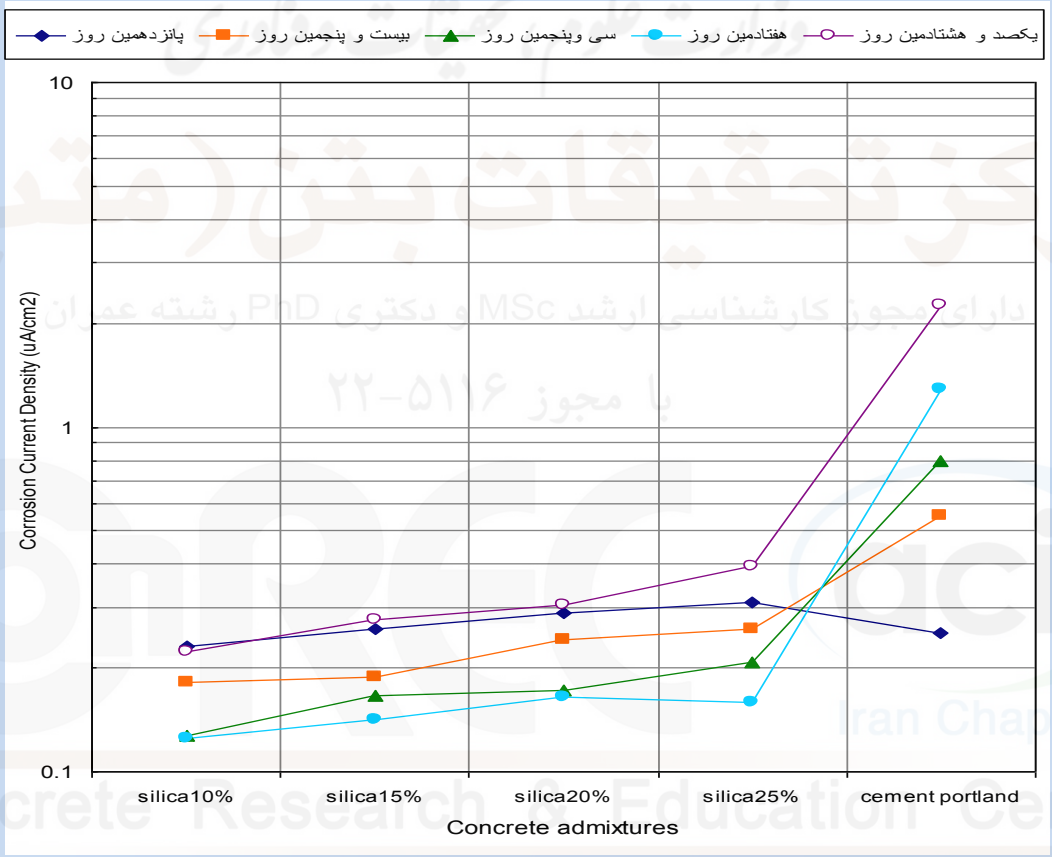
شکل۳- ۹- منحنی پلاریزاسیون فولاد در مخلوط بتنی با ۱۰٪ پودر سیلیس در محلول ۳/۵٪ NaCl



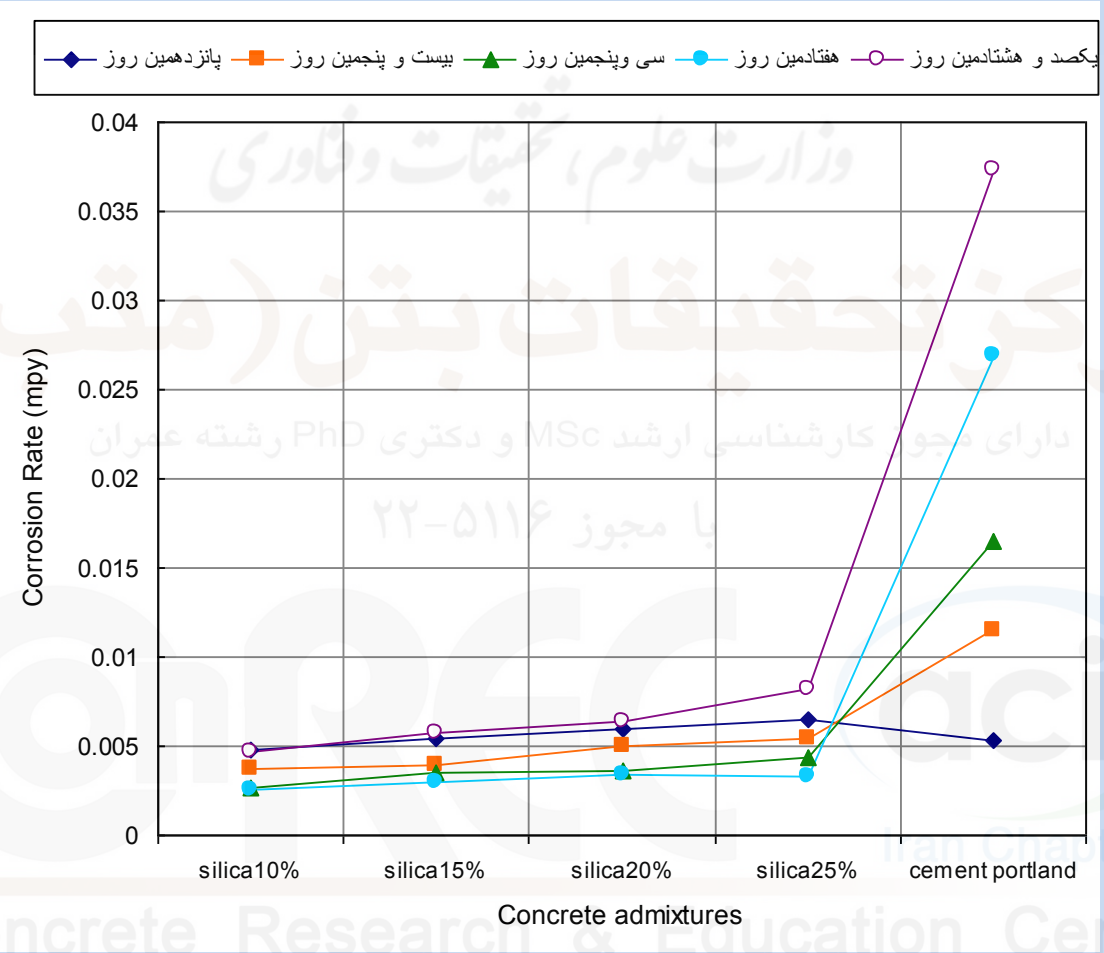
شکل۳- ۱۳- منحنی پلاریزاسیون فولاد در مخلوطهای بتنی با ٪۱۰ و ٪۱۵ و ٪۲۰ و ٪۲۵ پودر سیلیس در پانزدهمین روز قرارگیری نمونه ها در محلول ٪۳/۵ NaCl .



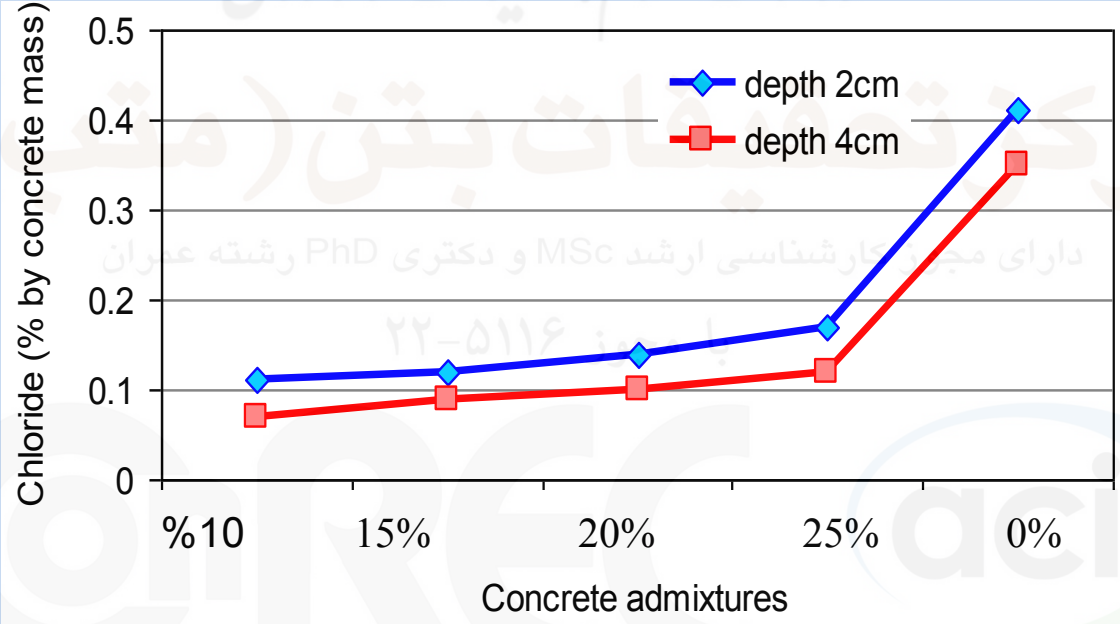
شکل۳- ۱۷-منحنی پلاریزاسیون فولاد در مخلوطهای بتنی با ٪۱۰ و ٪۱۵ و ٪۲۰ و ٪۲۵ پودر سیلیس در یکصد و هشتادمین روز قرارگیری نمونه ها در محلول ٪۳/۵ NaCl.



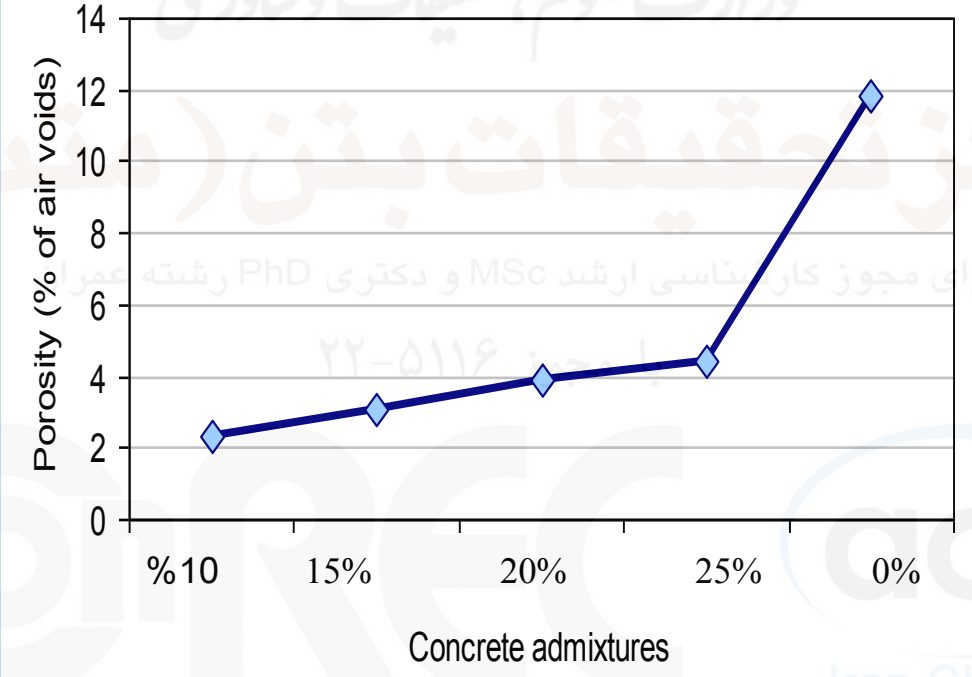
شکل۳- ۱۸- تغییرات دانسیته جریان خوردگی فولاد در مخلوطهای مختلف بتنی با افزودنی پودر سیلیس با گذشت زمان قرارگیری در محلول ۳/۵٪ کلرید سدیم.



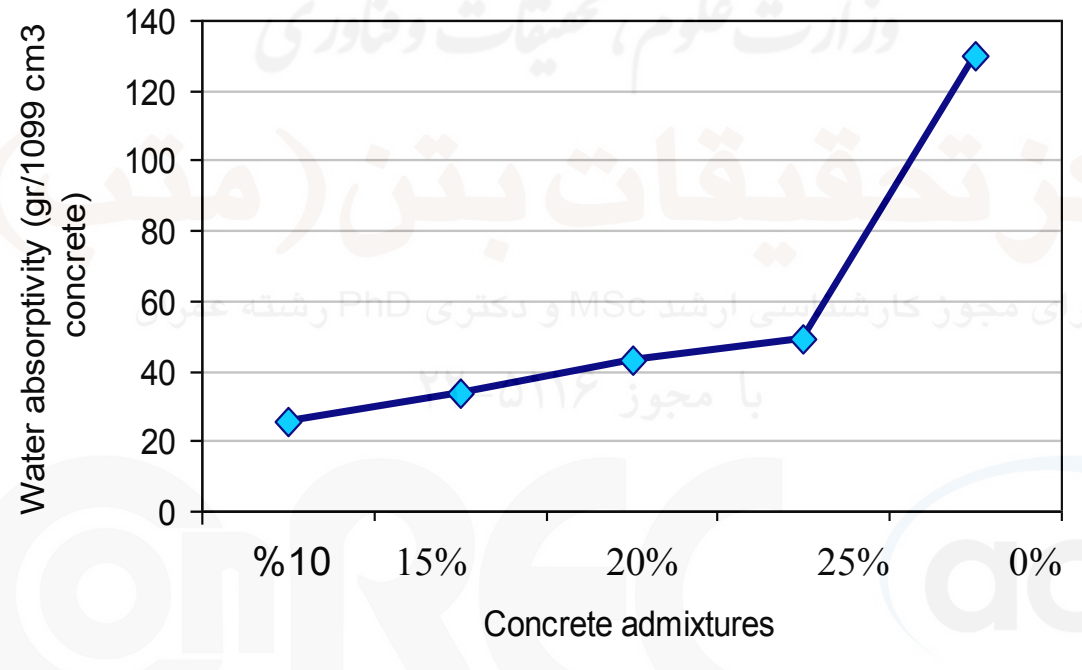
شکل۳- ۲۰- تغییرات نرخ خوردگی فولاد در مخلوطهای مختلف بتنی با افزودنی پودر سیلیس با گذشت زمان قرارگیری در محلول ۳/۵٪ کلرید سدیم.



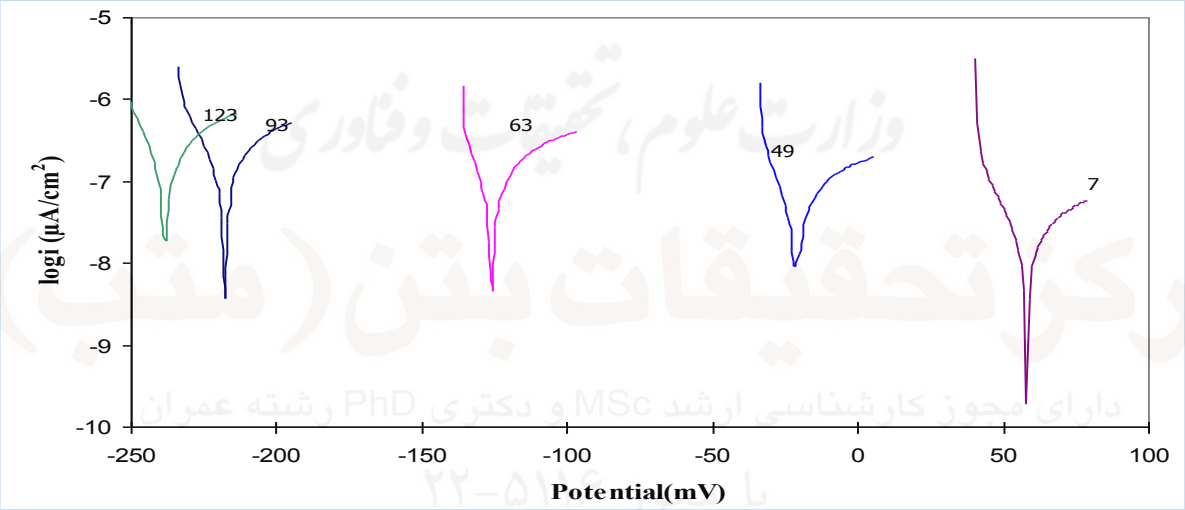
شکل۳- ۲۱- درصد یون کلر برحسب وزن بتن در مخلوطهای مختلف بتنی در محلول ۳/۵٪ NaCl به مدت ۱۸۰ روز.



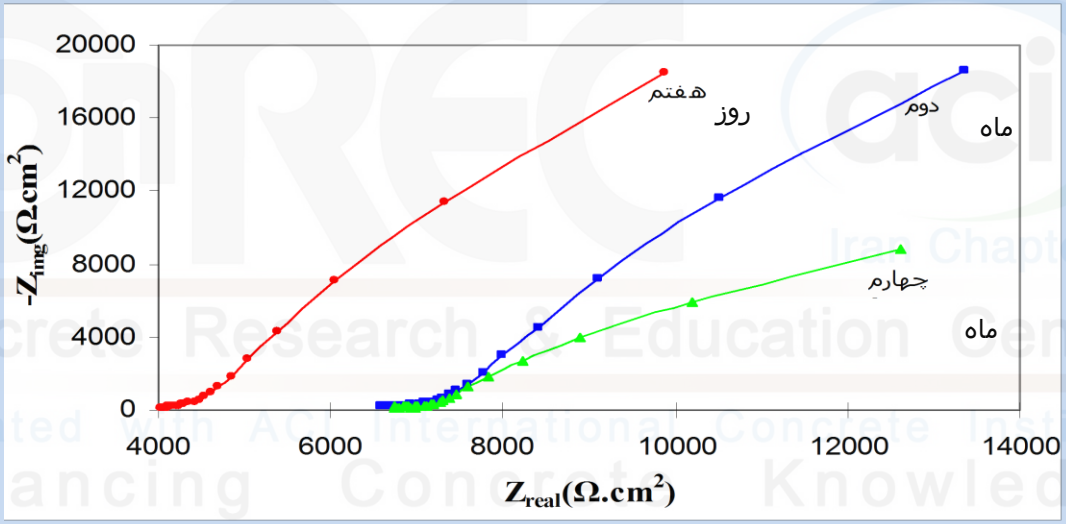
شکل۳- ۲۳- درصد تخلخل مخلوطهای بتنی با افزودنیهای پودر سیلیس که به مدت ۱۸۰ روز در محیط آبی قرار داشته اند.



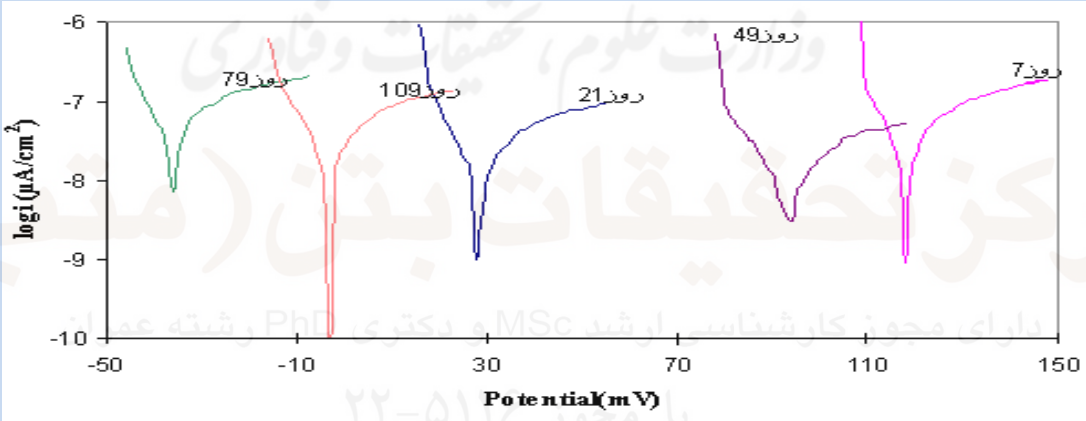
شکل۳- ۲۴- میزان جذب آب در مخلوطهای بتنی با افزودنیهای پودر سیلیس غوطه ور به مدت ۱۸۰ روز در محیط آبی



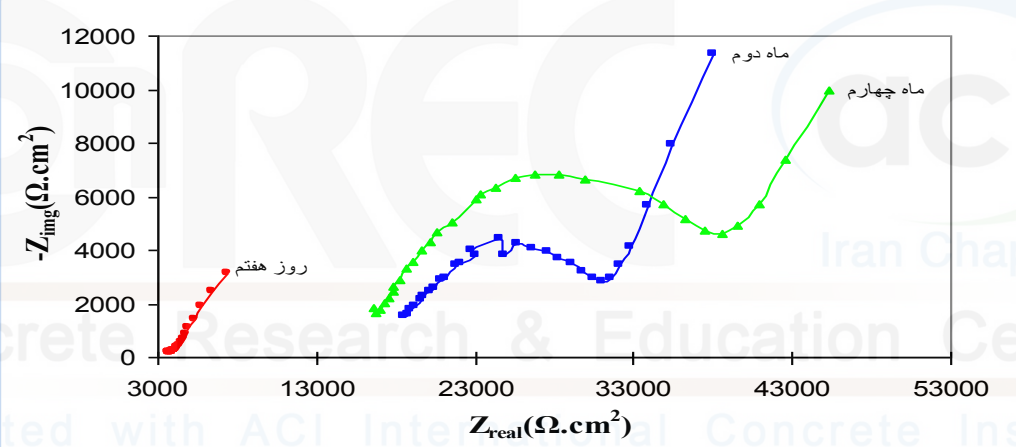
شکل۳- ۲۵- منحنی های پلاریزاسیون خطی برای بتن غوطه ور در آب دریا با نسبت آب به سیمان ۰/۴۵



شکل۳- ۲۶- منحنی های امپدانس الکتروشیمیایی برای بتن غوطه ور در آب دریا با نسبت آب به سیمان ۴۵/



شکل۳- ۳۵- منحنی های پلاریزاسیون خطی برای بتن حاوی ۱۰٪میکروسیلیکس غوطه ور در آب شیرین



شکل۳- ۳۶- منحنی های امپدانس برای بتن حاوی ۱۰٪میکروسیلیس غوطه ور در آب شیرین

*** نتایج افزودن میکرو سیلیس :**

۱- مواد افزودنی میکروسیلیس ۴- ۱۰٪ وزنی سیمان ، جهت افزایش مقاومت به خوردگی بتن

۲-میزان تخلخل با افزایش میکرو سیلیس کاهش قابل توجهی نشان می دهد.

۳- میزان نفوذ پذیری یون کلرید با حضور میکرو سیلیس کاهش یافته

۴-افزایش مقاومت بتن با افزایش میکرو سیلیس

۵- رفتار پلاریزاسیون بتن در حضور یون کلرید بدون رفتار پاسیواسیون بوده و با افزودن سیلیس مقاومت پلاریزایون بالا رفته و حد مجاز

موفق باشید

PS 1000 X-Scan
Product Training

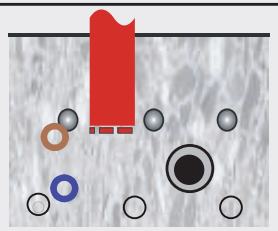
Don‘t chance it! Check before you drill or core

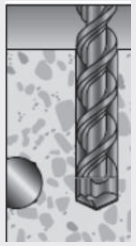
PS 1000 X-Scan: First Easy to Use Pulse Radar Based Detection Tool

- **Localization:** Locates objects in multiple layers up to 30 cm in cured concrete
- **Hit Prevention:** Helps users to find safe spots to drill, core or saw
- **Structural Analysis:** provides data analysis, evaluation and report generation

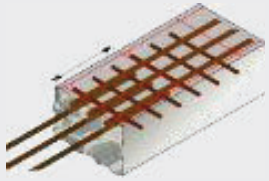
PS 1000 X-Scan covers both main application fields: Hit prevention & Structural analysis

Hit prevention





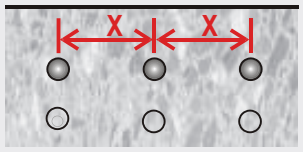
Safe drilling / coring / sawing



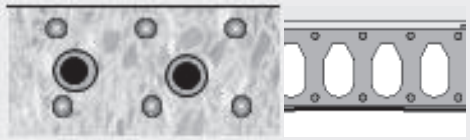
Rebar extension

Locating pipe & cable runs

Structural analysis



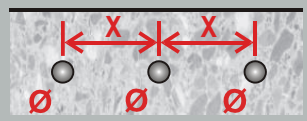
Rebar verification: layout, spacing, layer



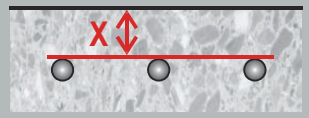
Verification of PT-Cable, curvature, depth, density

Documentation, report & archive

Structural analysis



Rebar verification: layout, spacing, diameter



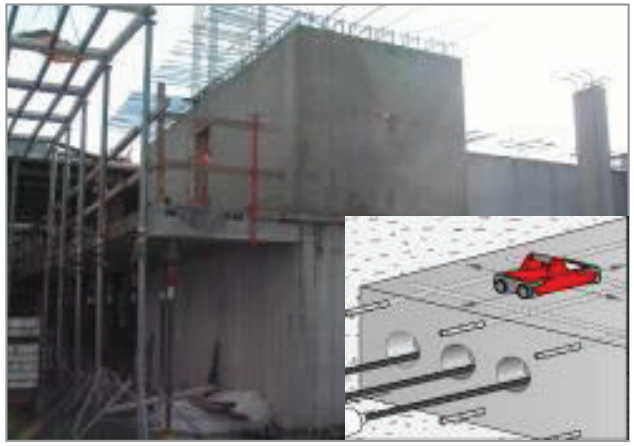
Concrete coverage: corrosion & fire protection

Documentation, report & archive

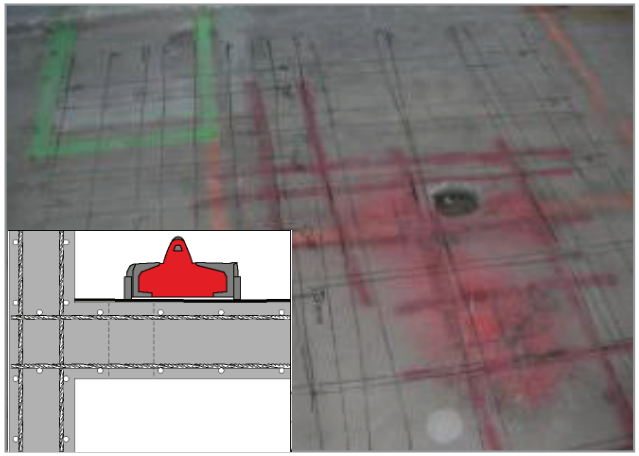
PS 1000

PS 200/PS 250

Key application fields for a wide variety of customers

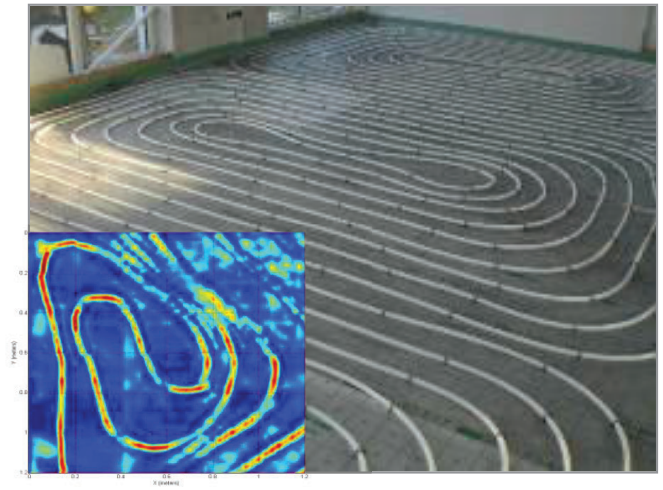


Drilling/coring in concrete structures



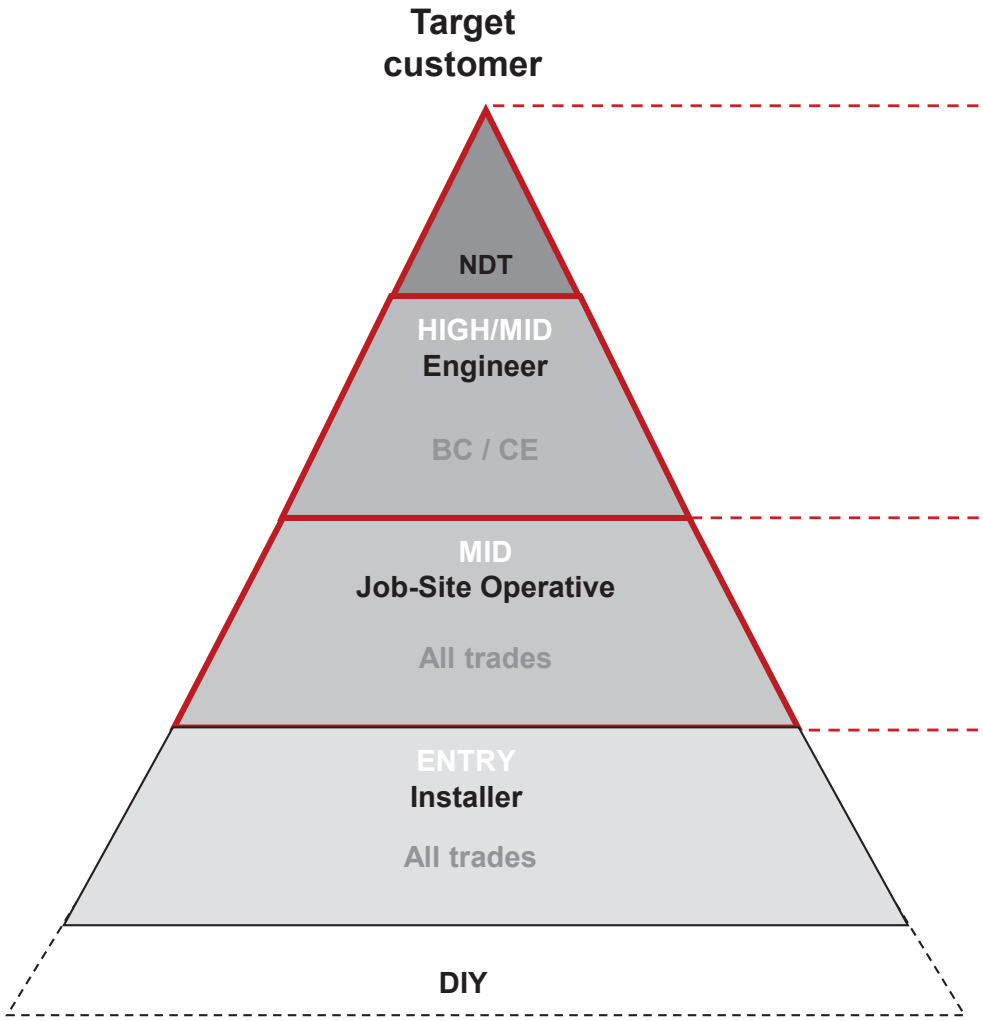
Marking layout of embedded objects in structures for drilling e.g. rebar, conduit

Non-destructive inspection of bridges e.g. location of tendons



Locating objects in floor e.g. heating pipes

What do customers want in each segment?



Customer requirements:

- High reliability
- Advanced data analysis
- Enhanced visualization (raw to processed)
- Fast and easy set up
- Compatibility and interface to PC, monitor and PS 200 Ferroscan data

- High reliability
- Interpretation free visualization
- Easy direct layout marking: Quick set up, scan, detect and mark

PS 1000 X- Scan complete system components

Scan

Scan & analyse & mark

transfer scans

Organize / Analyse

Jobsite

transfer scans

Analyse, Report, Archive

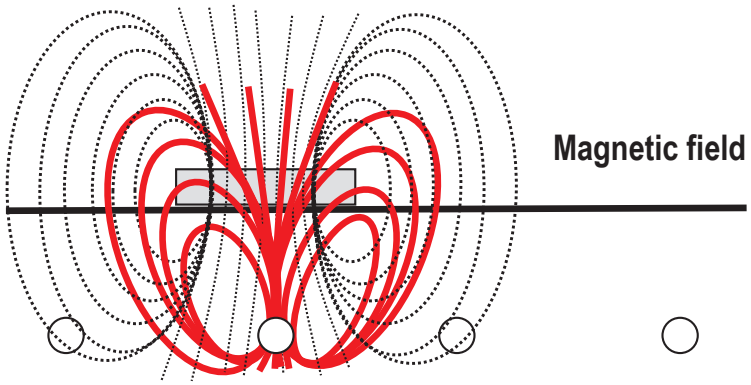
Office

Scanning and marking object layout quickly and easily – no expert skills required!

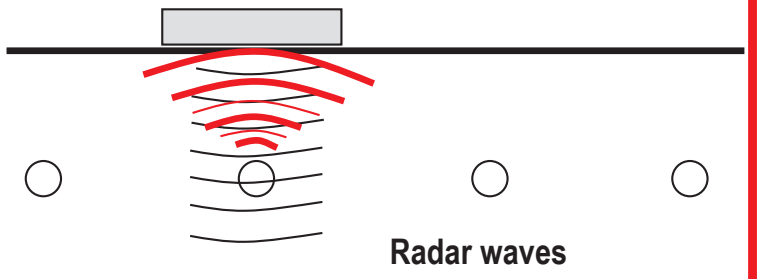
PS 1000 X-Scan
Product Training

Detection principles for the Non Destructive Testing

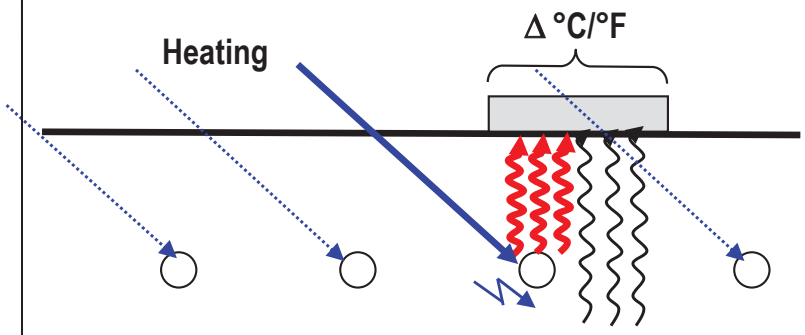
1. Magnetic Induction



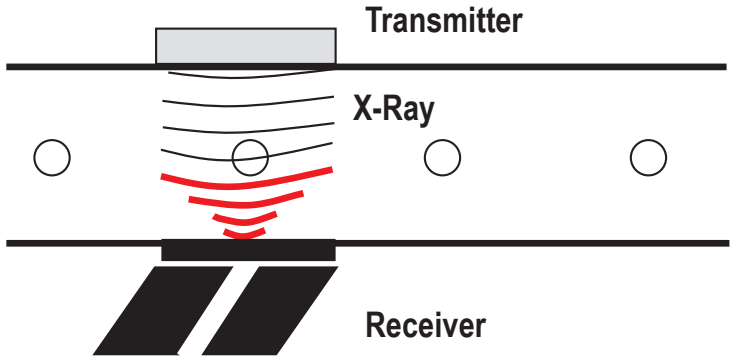
2. Reflection



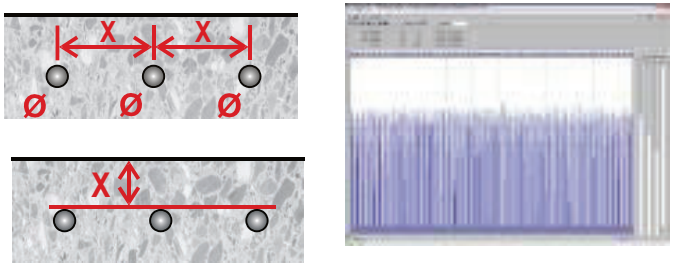
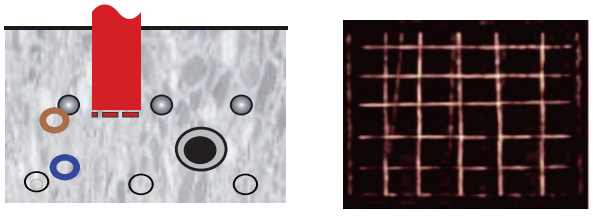
3. Thermostatic



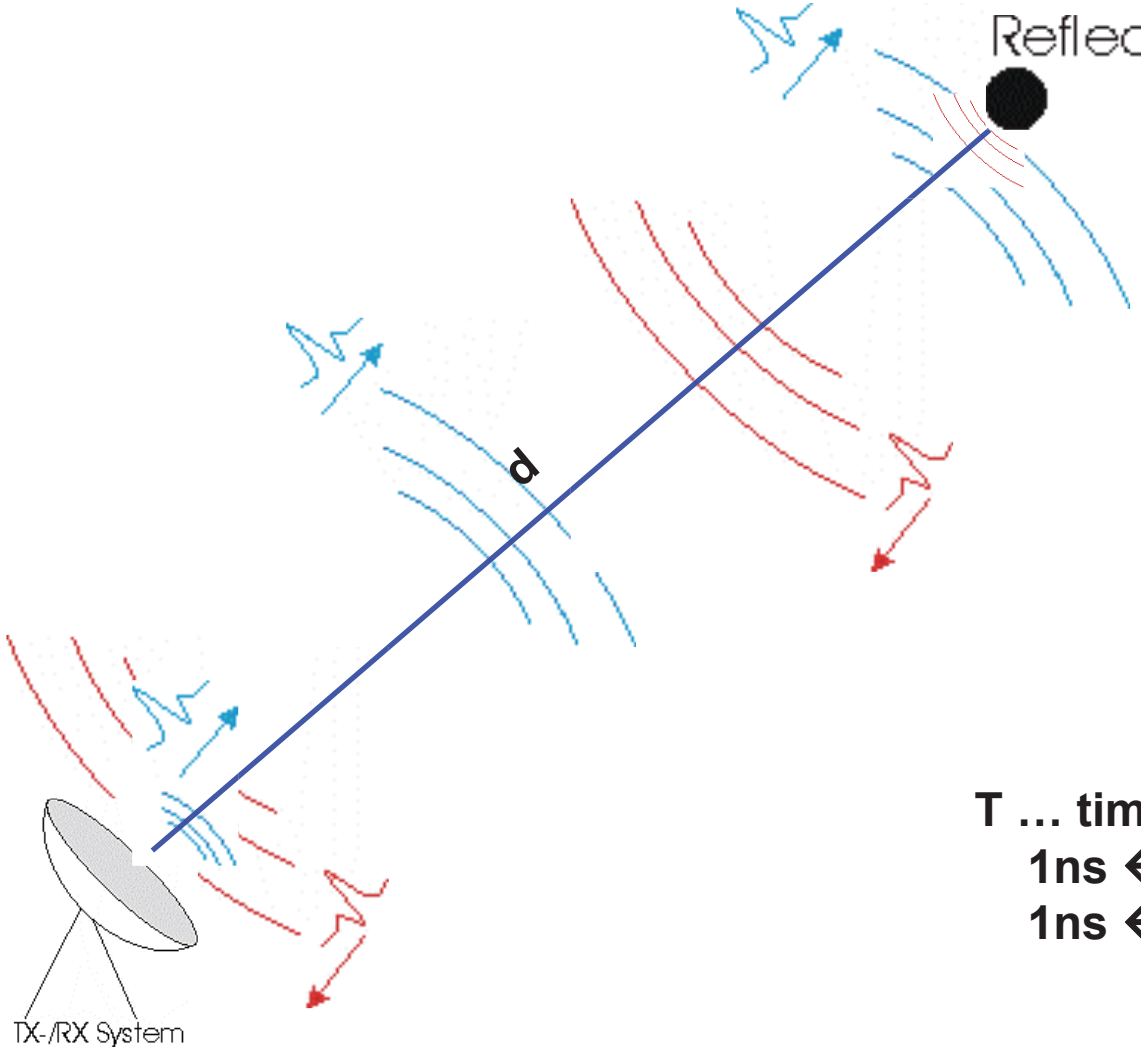
4. Radiography



Safe drilling and structural analysis are the main applications of both detection methods

Technology	Application	
Magnetic Induction	Reinforcement analysis 	• Rebar detection/layout • Concrete coverage • Rebar diameter • Measuring areas, analysis, statistics, reporting
Pulse Radar	Safe drilling & structure analysis 	• Detection of embedded objects in different layers • Safe drilling • Measuring of slab thickness • Measuring areas, analysis, reporting

Radar: Basic principle I



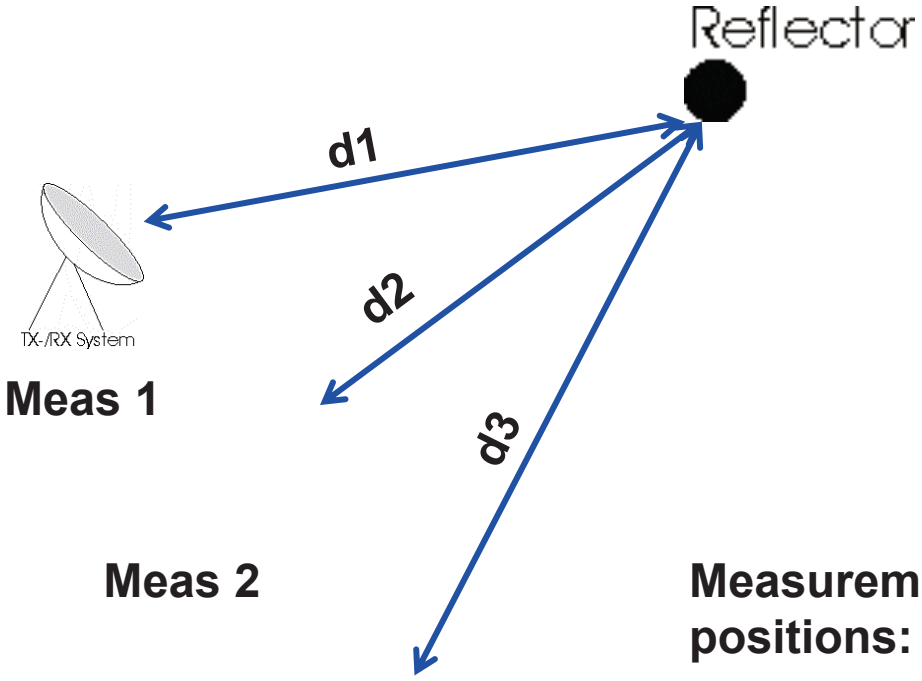
$$T = \frac{2^{*}d}{v}$$

T … time of flight = function of d AND v!
1ns ←→ 15cm in air
1ns ←→ 4 .. 12 cm in concrete

Radar: Basic principle II

How to reconstruct the position out of the measurments…

Measurements

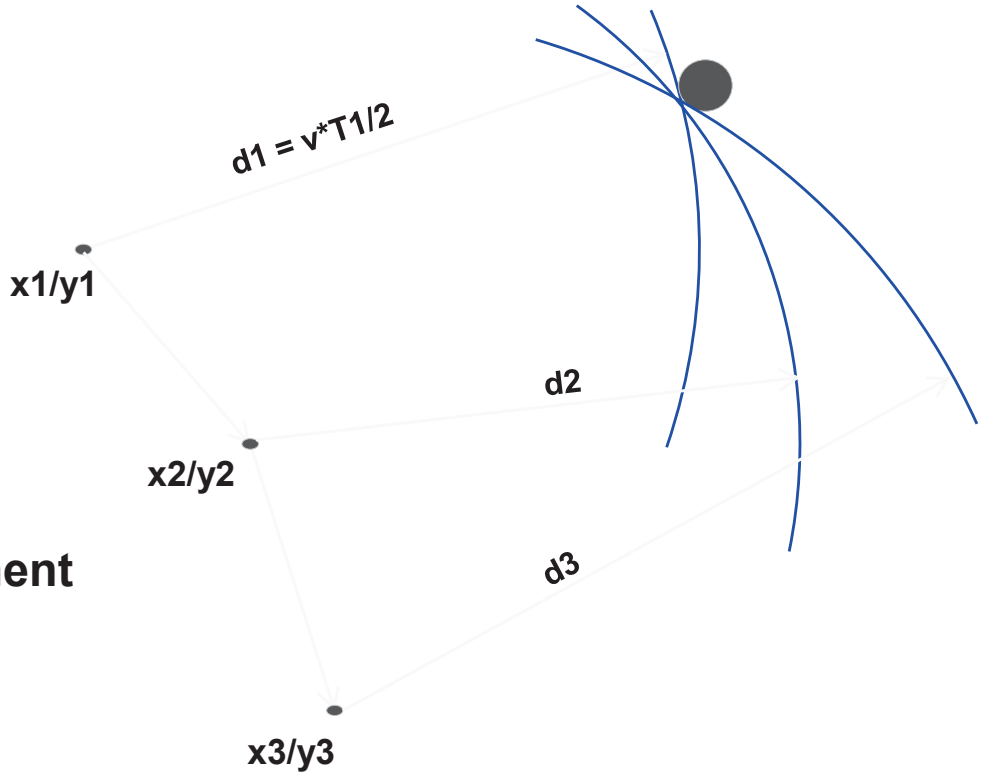


Meas 1

Meas 2

Meas 3

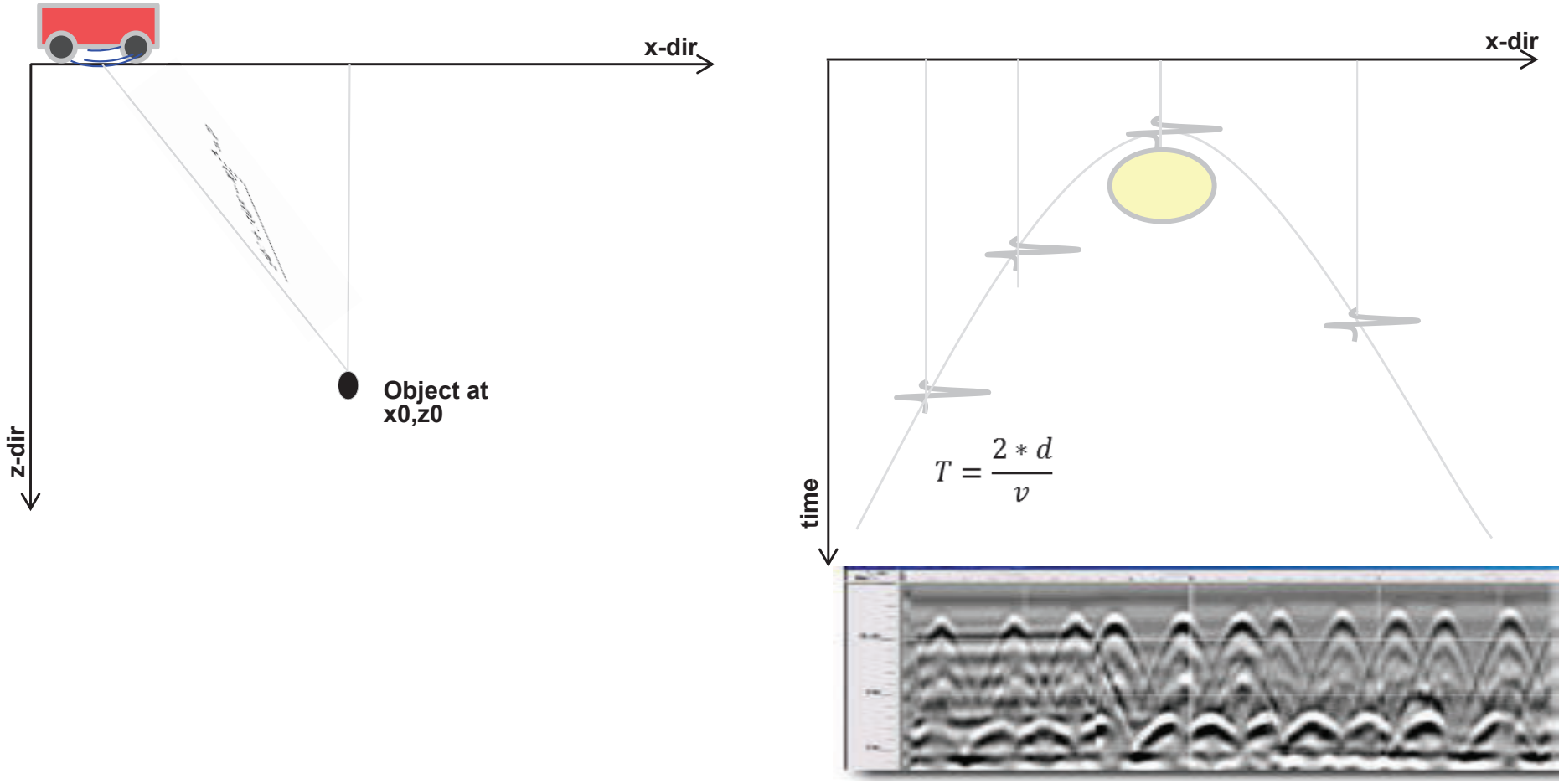
Reconstruction: Where is the Object?



Measurement positions:

→ **More than one measurement necessary to localize one object**

Radar: Basic principle III

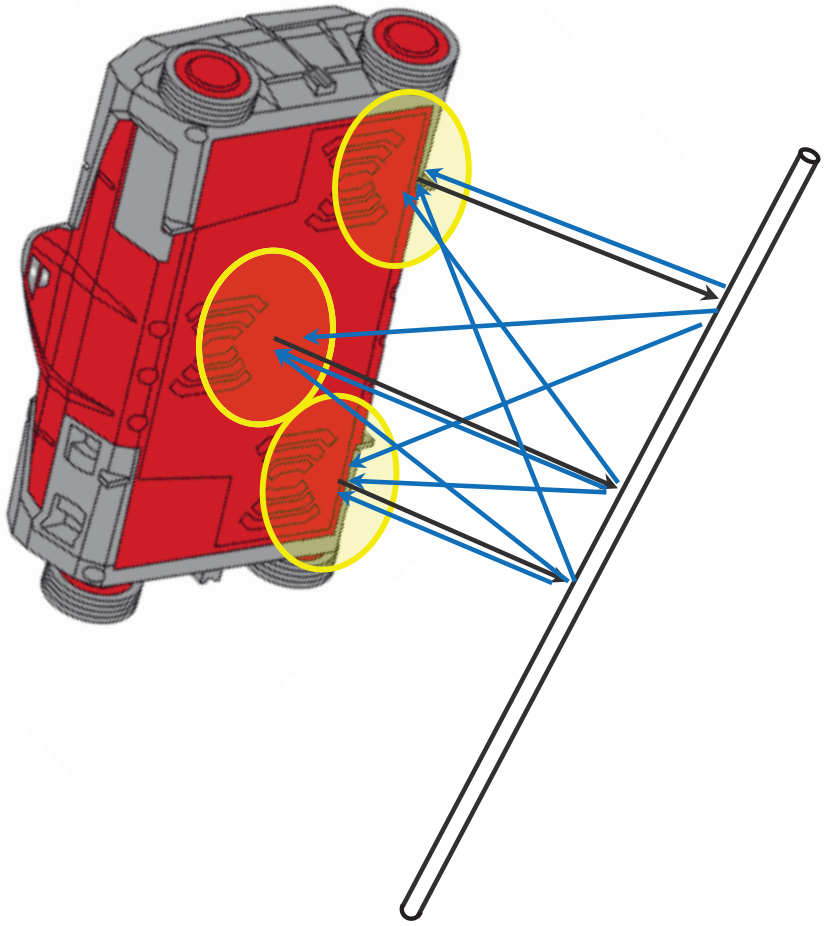


→The Apex of the curve indicates the position of the object in x and z-direction (curves are called «Detection Hyperbolas»)

Radar: Antenna Array I

- Only one Transmitter active at one time
- All Receivers are active all the time

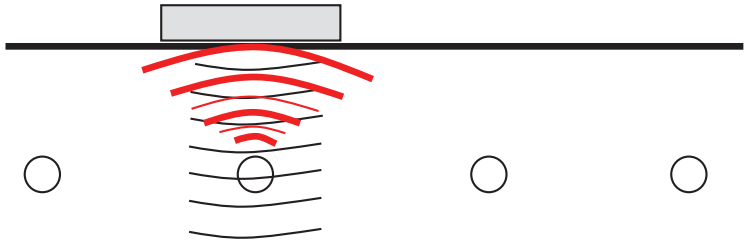
→ Monostatic channels
→ Bistatic channels

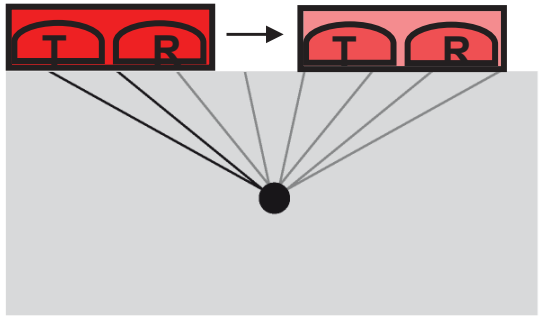


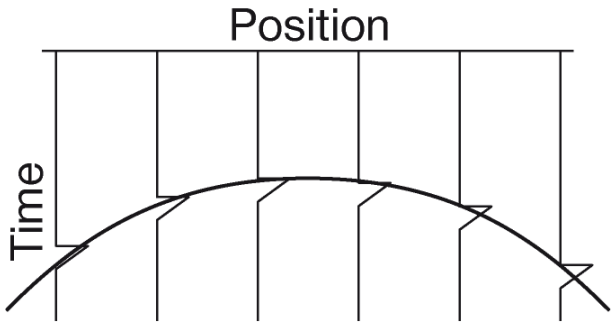
Why is three better than one?

Three antennas ensure:
- Higher productivity
- Better data quality
- Better vertical resolution

Measuring Principle : What is Ground/Wall Penetrating Radar



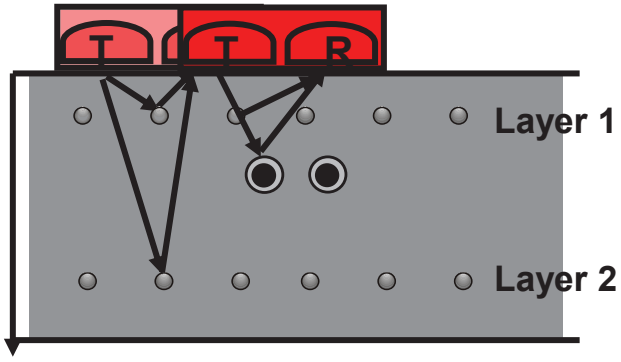




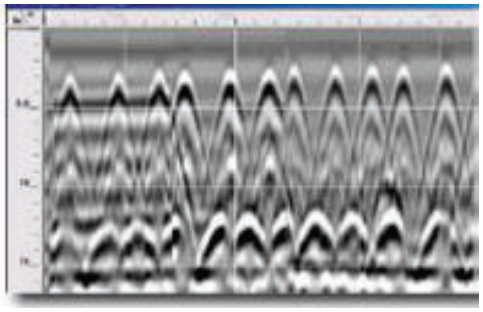
T= Transmitter
R= Receiver

The PS 1000 X-Scan uses 3 antennas which emit and receive pulses of electromagnetic energy through concrete. The reflection is measured by all three antennas. The transmitting is consequently done by all three antennas

When scanning the concrete, the pulses are reflected by the embedded objects, analysed by the tool and immediately represented on the display.



Time/Depth



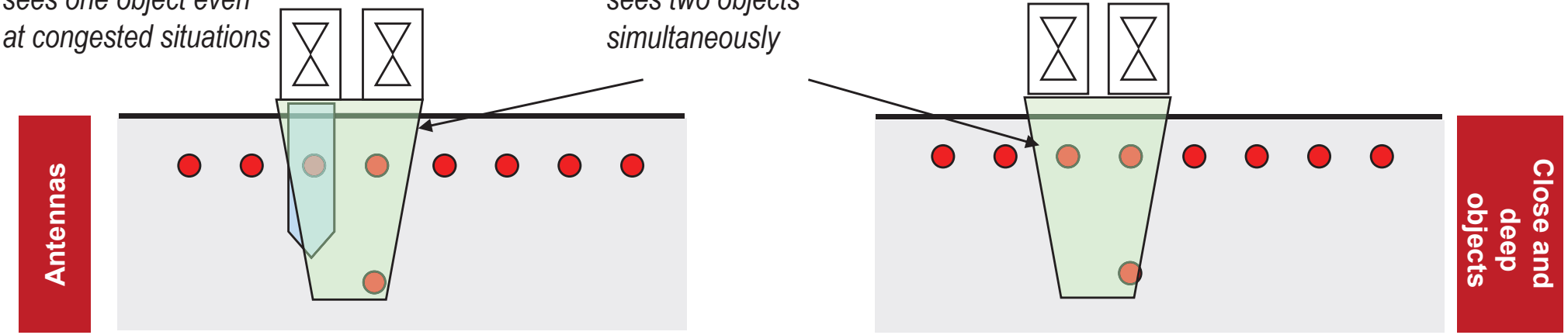
Antenna configuration and higher bandwidth lead to better performance

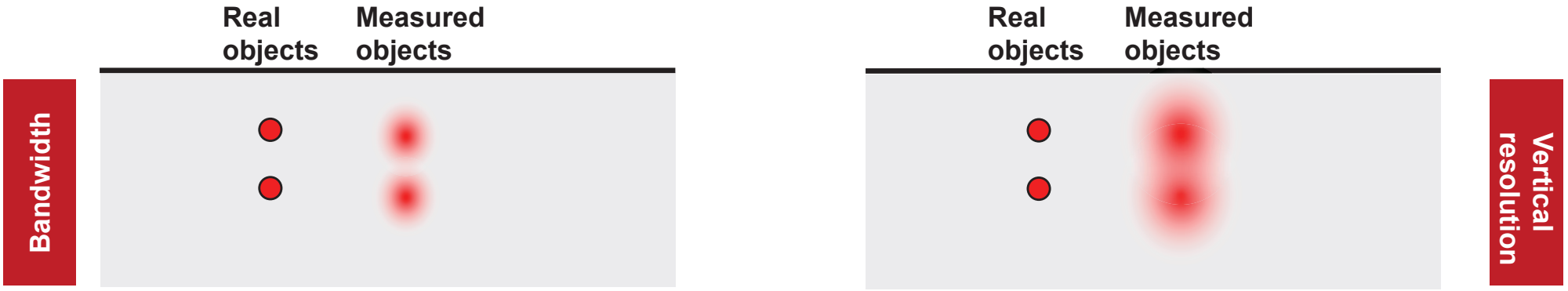
PS 1000

Monostatic antenna sees one object even at congested situations

Bistatic configuration sees two objects simultaneously

Competition

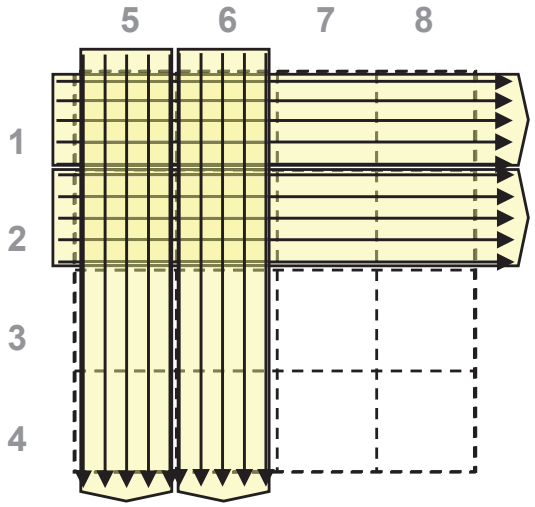




Optimized object detection over the whole depth range

Antenna array saves time and yields higher data quality

PS 1000

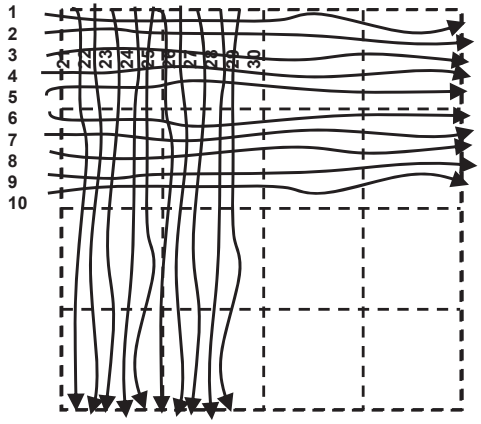


One sweep records 5 traces at once

*A total of **8** sweeps required for an area of 600x600mm*

- **Better data quality/density due to fixed antenna position of array - faster recording**
- **Regular recording brings higher localization accuracy and allows better 3D migration**
- **Allows real time top view representation of the data in QS mode**

Competition



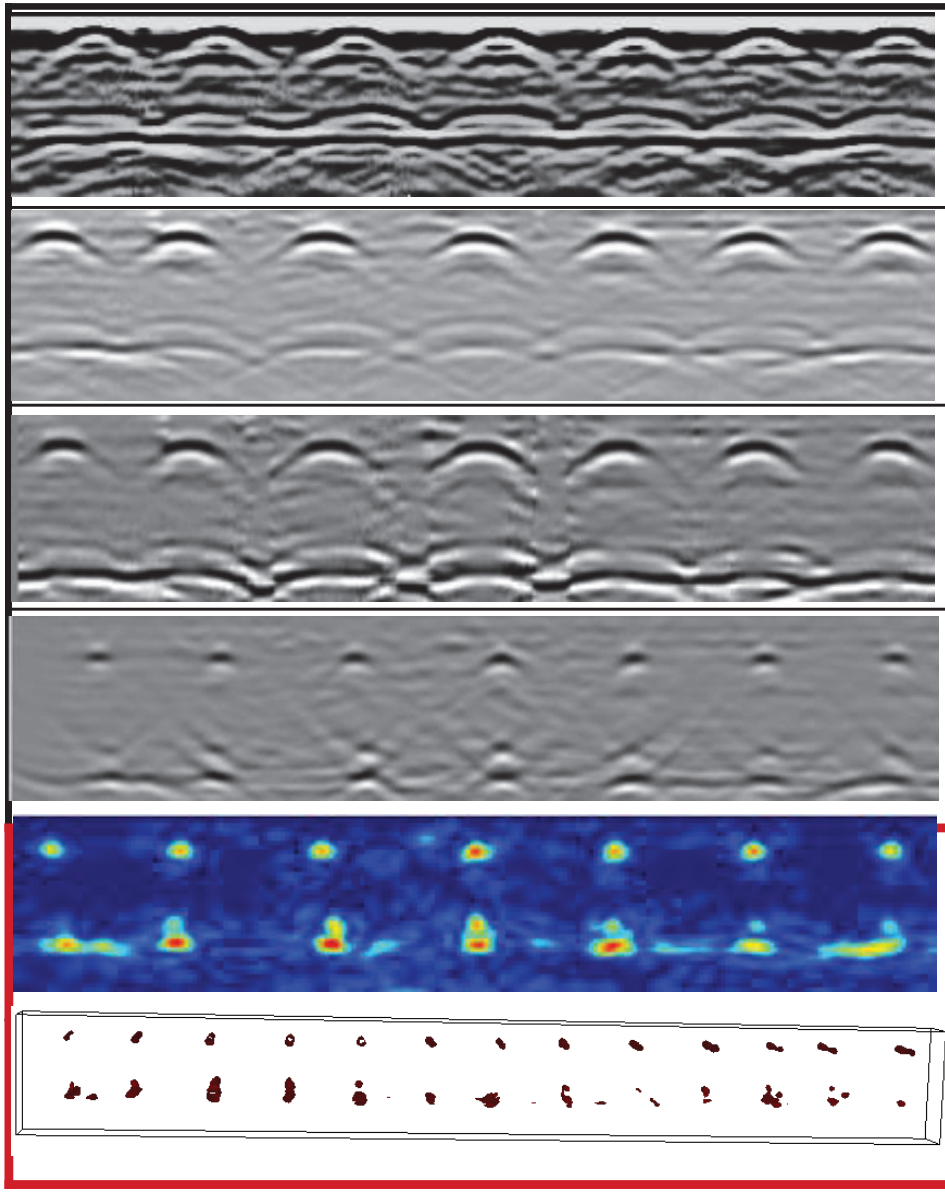
One sweep records only one trace

*A total of **40** sweeps required for an area of 600x600mm*

- **With a single antenna each trace has to be scanned manually**
- **Using a single antenna system one has to do 5x more sweeps for the same density of data**

80% productivity gain!

Process steps of data analysis

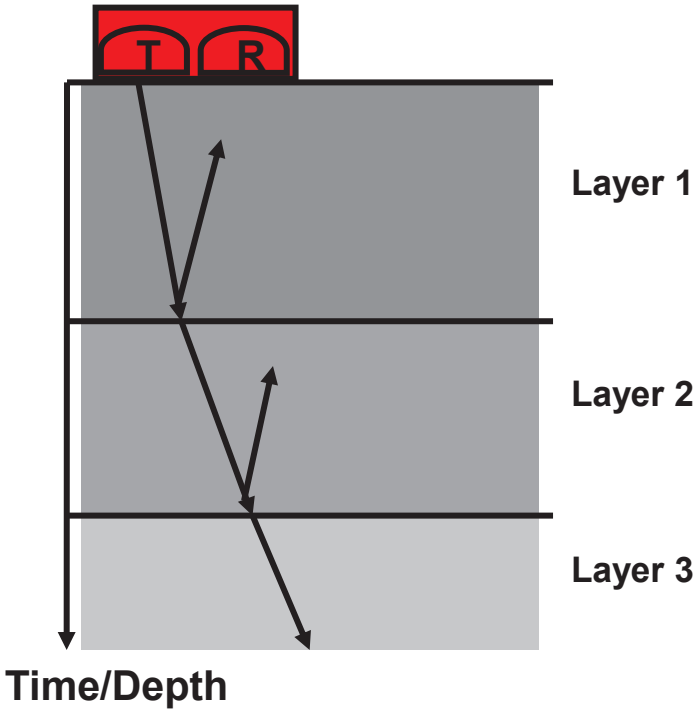


1. Raw
2. Filtered
3. Amplified
4. Focused (migrated data)
5. Default (post processed data)
6. Migrated data in 3D view

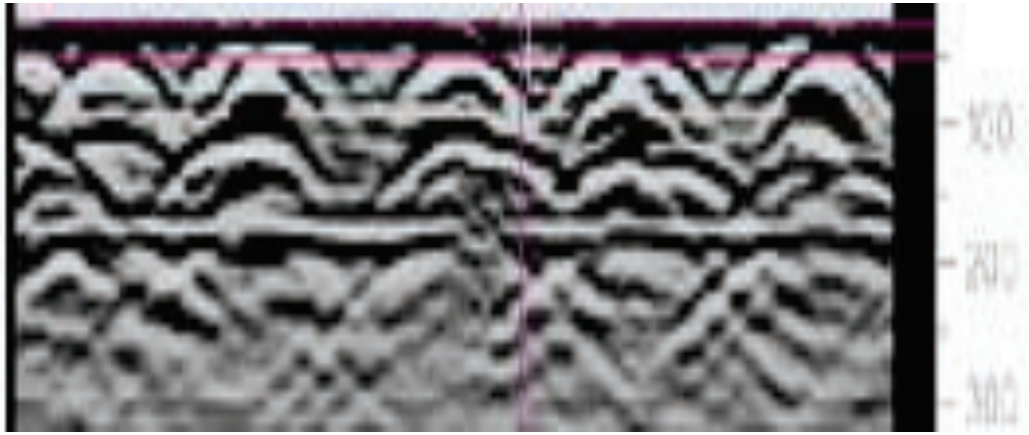
Non destructive testing, building diagnostics, layers

Safe drilling

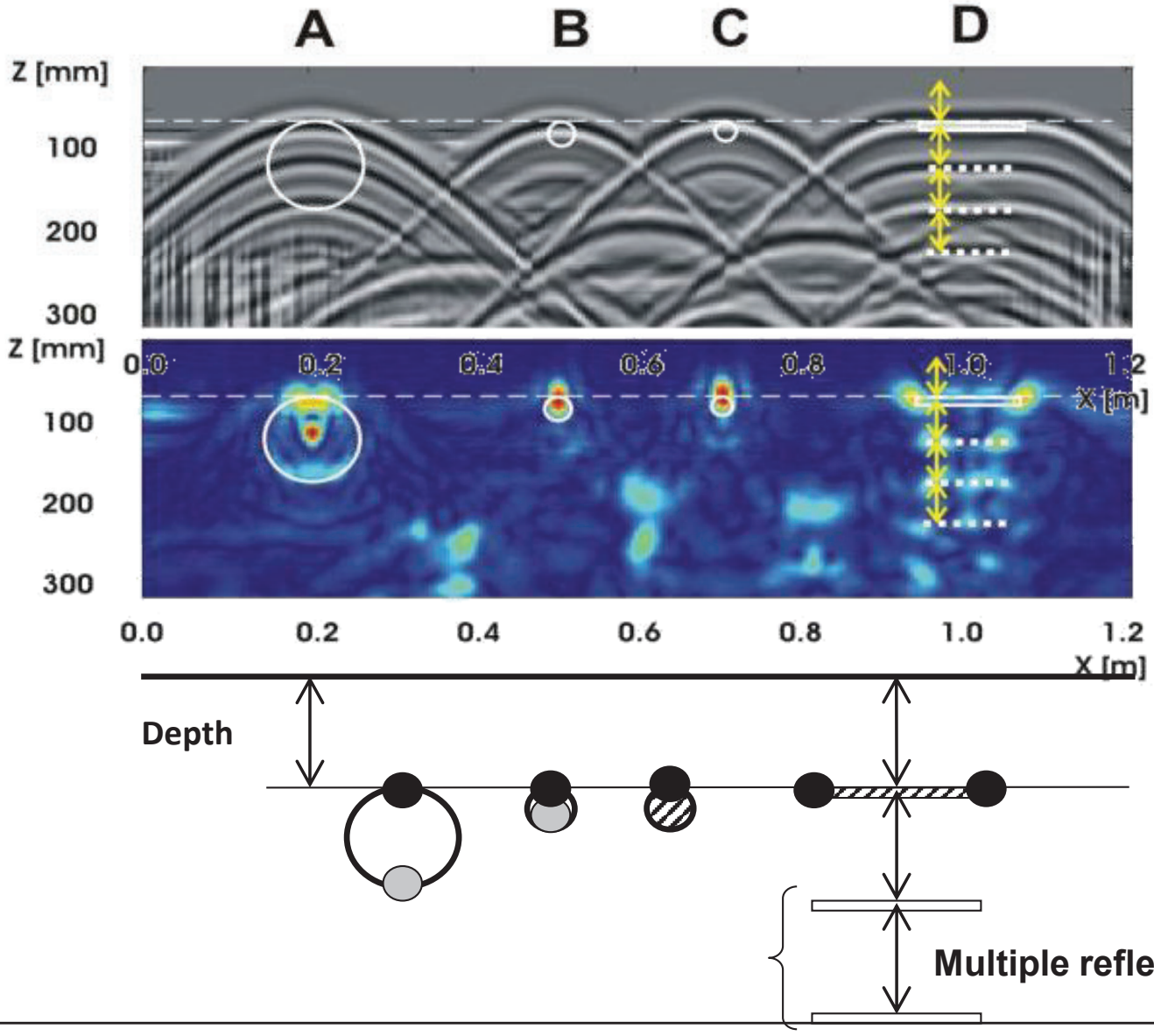
Evaluation of concrete thickness/layer



Radargram showing the reflection of the back of the wall/slab:



Depth indication of different objects and multiple reflections



A: empty wastewater pipe (70 mm Ø)
B: empty plastic pipe (25 mm Ø)
C: rebar (12 mm Ø)
D: metal plate (170 mm width)

Objects' depth: 70 mm

Middle point of the reflection top

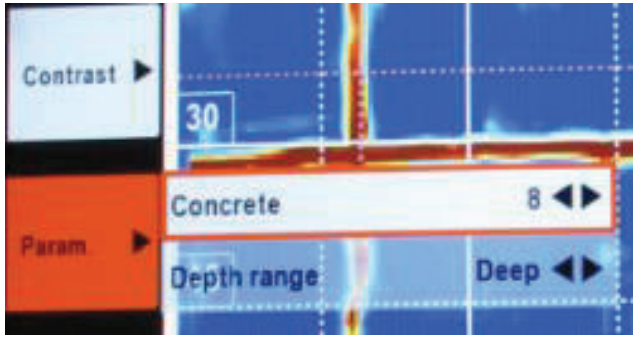
Middle point of the reflection bottom

Depth measurement accuracy with Pulse Radar depends on the permittivity of the concrete

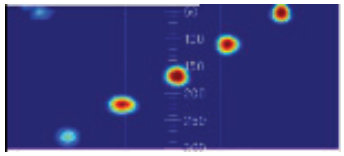
Options to derive the correct value:

1) Reference value:

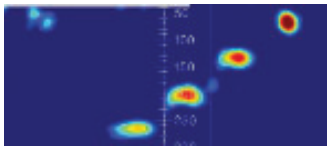
Typical parameter value for "concrete"	from	to
concrete	5	8
green concrete	6	12
dense concrete	6	9
granite	5	8
lime stone	7	9
sandstone	6	
asphalt	3	5



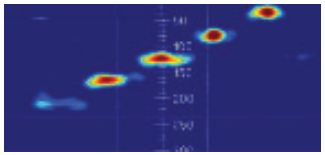
2) Verification with maladjustment:



Correct



Too low value

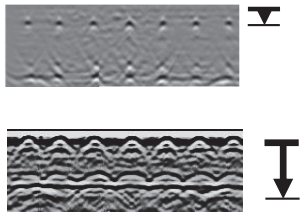


Too high value

3) Orientation based on known object depth

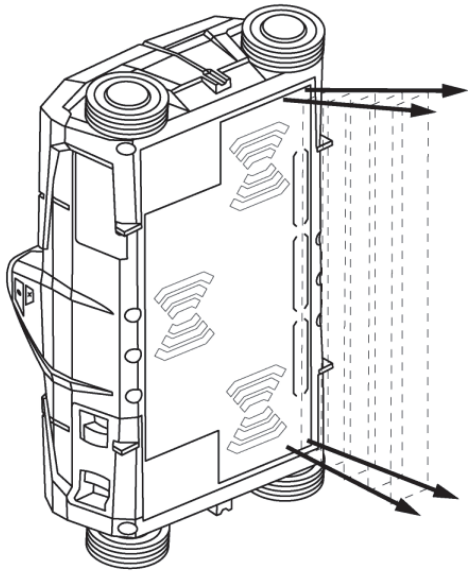
4) Orientation based on the wall thickness

Parameters adjustment until depth value is correct

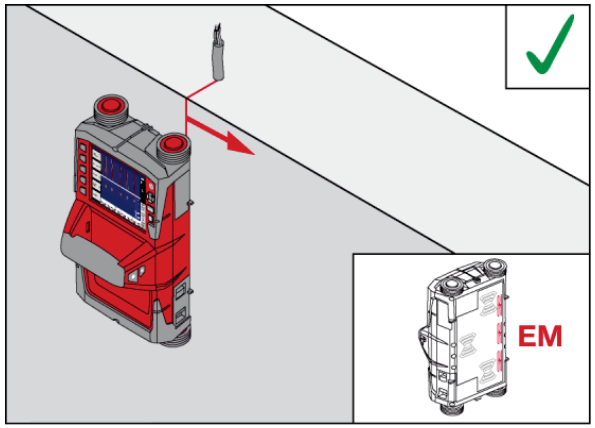


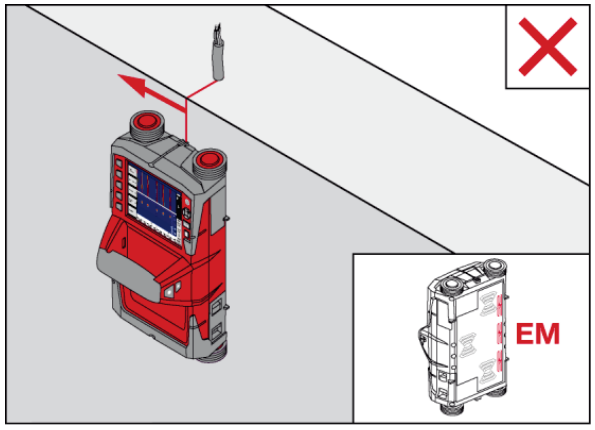
Next to a three antenna array users can benefit from an additional six coil EM sensor array

- EM sensor supports ease of interpretation of detected objects
- EM sensor classifies live electrical cables (loaded wires only!)
- EM sensor can be activated or deactivated depending on customer's needs
- EM senor sensitivity: double wire (d = 5 mm) in 8 cm depth with I = 250 mA (45 - 65 Hz)

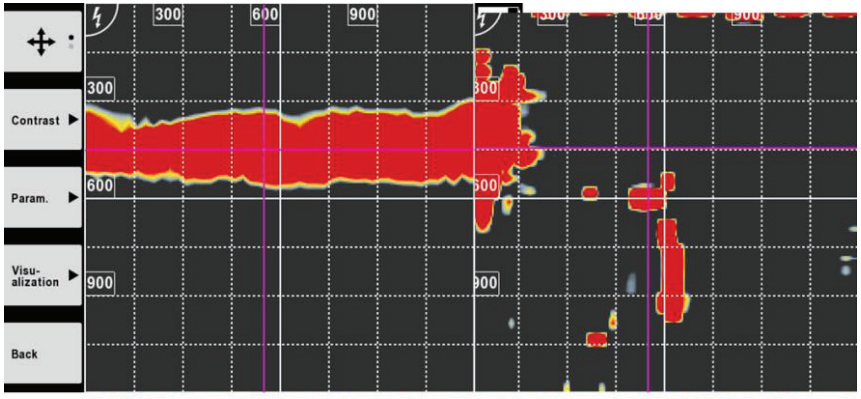


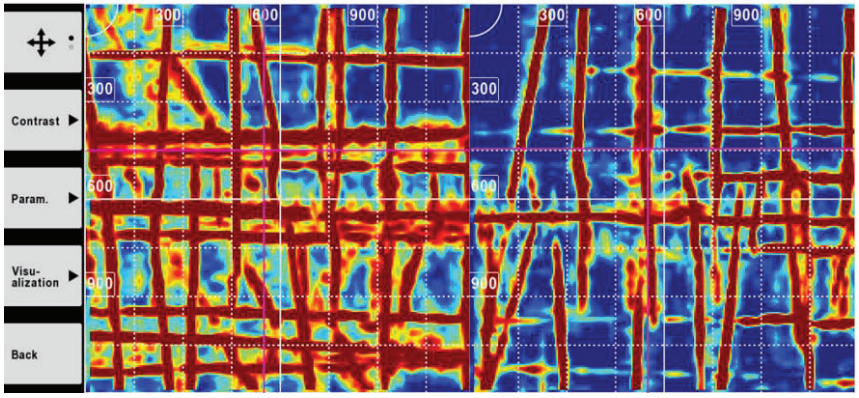
EM sensor array needs to pass object

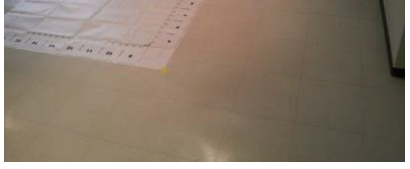




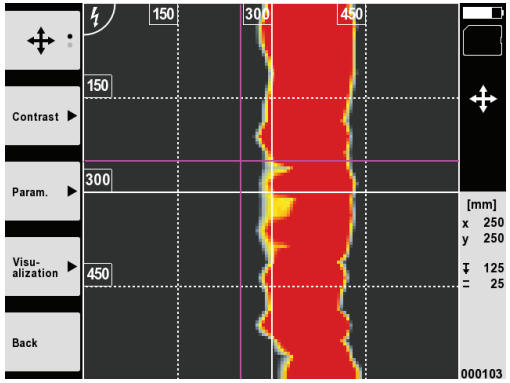
The EM – Sensor classification for live wire adds value to radar object visualization

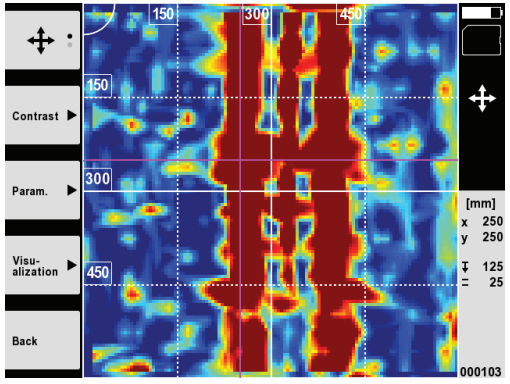




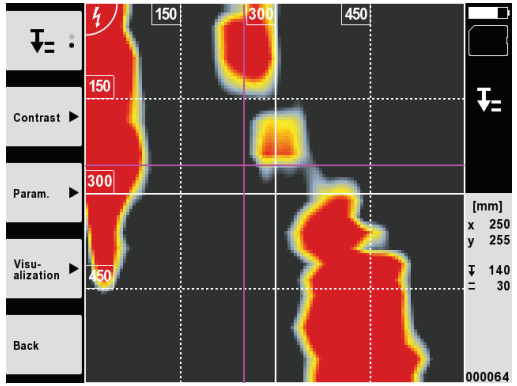


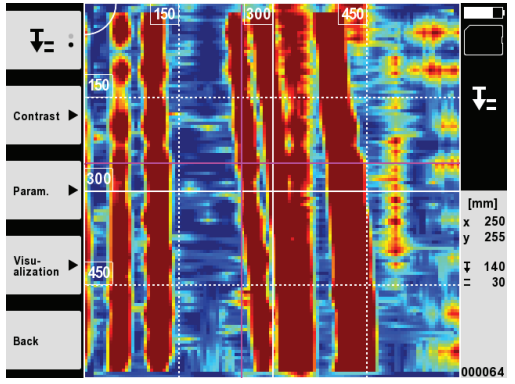
Cable bundle with outlet to bottom of slab, measurements fit plans exactly





Column with electrical conduit leading to an outlet on the bottom

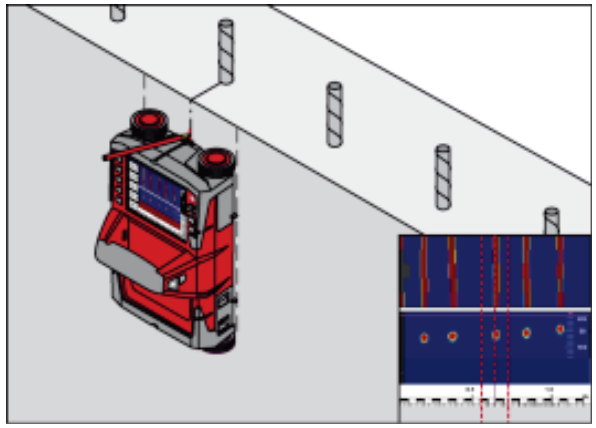




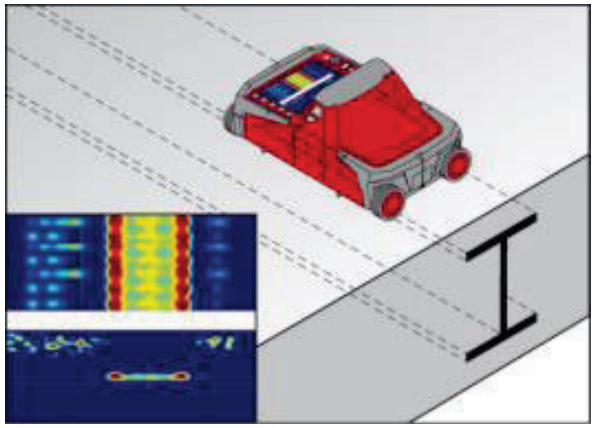
Floor scan with PT cables and electr. conduit

Detection applications

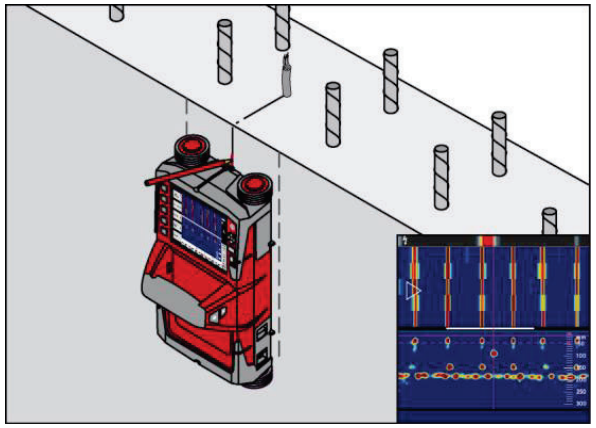
Quickscan



Object location

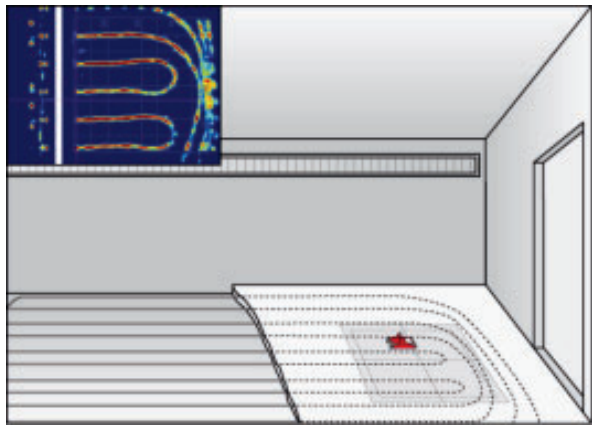


Plates location

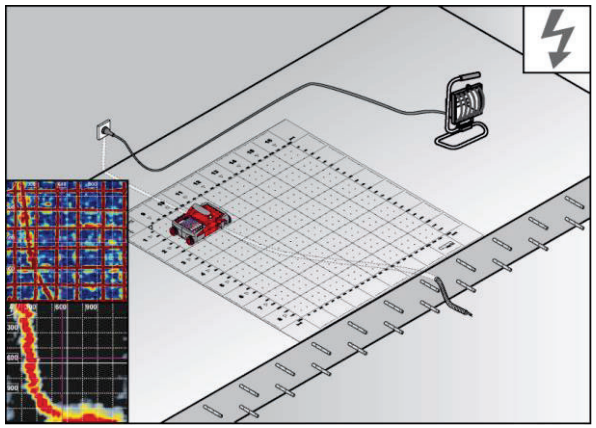


Live wire detection

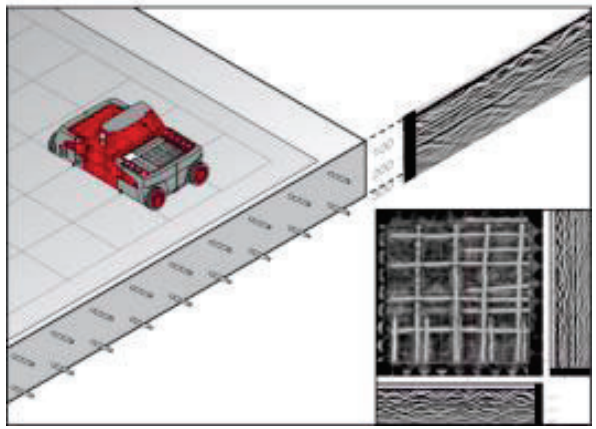
Imagescan



Floor heating



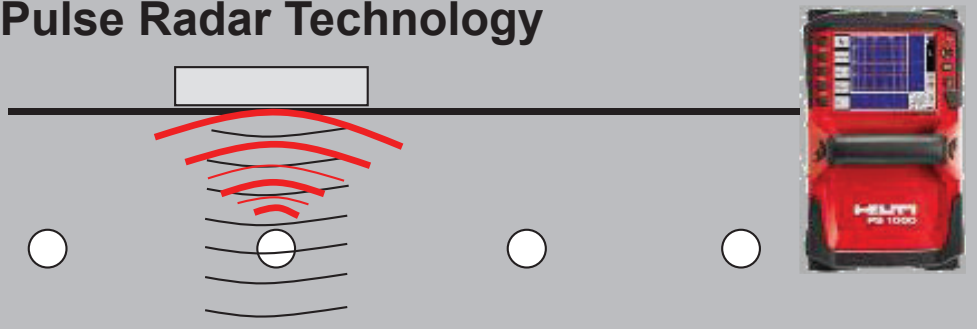
Object & Live wire detection



Slab thickness

High differentiation versus PS 200/PS 250
Ferroscan allows clear product positioning

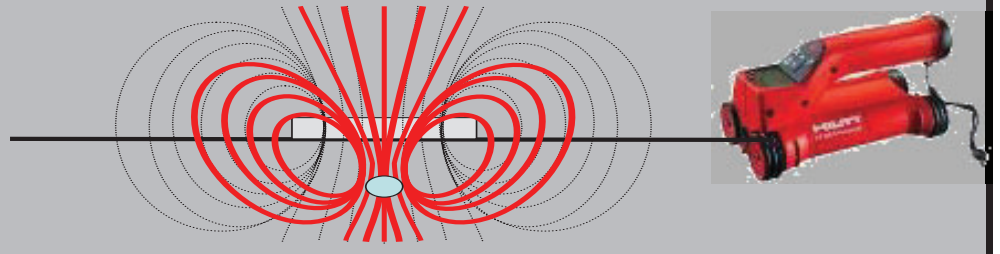
Pulse Radar Technology



- High detection depth (up to 30 cm in dry concrete)
- Multiple layer detection possible
- Imaging of plastic pipes and non-metallic objects possible
- Detection of large diameter objects possible
- Indication of object depth

➢ Ideal for drilling tasks

Magnetic induction Technology



- Exact depth determination (cover meter function)
- Diameter estimation possible
- Rebar layout, spacing up to 16cm depth – up to first layer

➢ Ideal for quality assessment of concrete structures

Technology limitations

Scanning performance depends on:

- **Concrete condition**
  - Reduced depth range and depth accuracy if concrete is not cured/wrong concrete setting chosen
  - Amount of aggregates, high density concrete
  - Rough surface (use overlay)
- **Multiple layer structure**
  - Every additional layer gives some reflections and prevents from deeper detection performance
- **Rebar layout:**
  - Detection range / Multiple layer object detection is reduced when rebar grid is <13cm
- **Electrical cable detection:**
  - No current loaded, too deep embeddment depth, metail conduit (shielding too high)

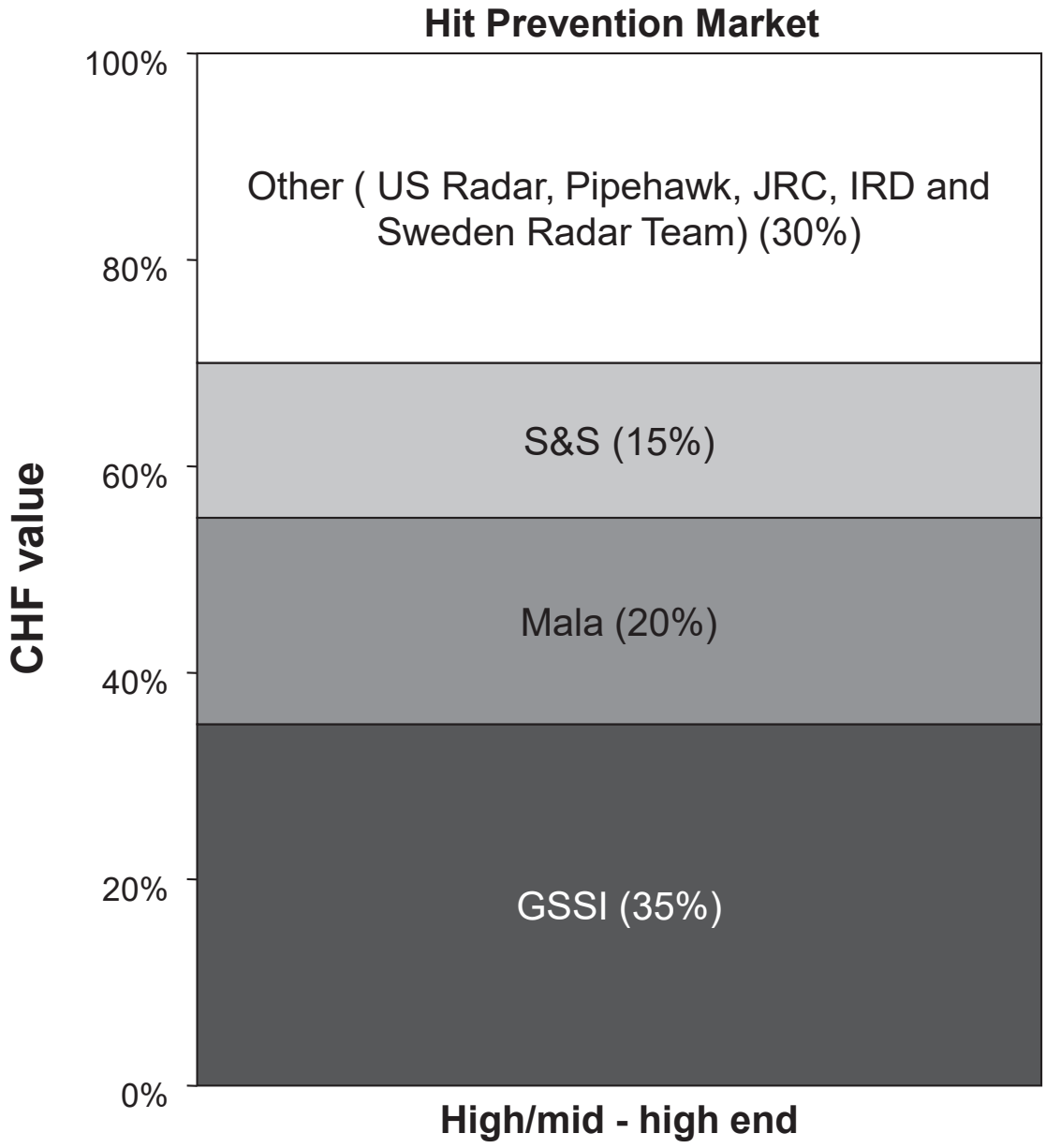
PS 1000 X-Scan
Product Training

Target of PLS detection: become #1

1	Become #1 in detection market – develop business from specialist business to mainstream business	Penetrate all relevant Hilti trades / segments and develop/expand market
2	Right Detection Tool for all Hilti Core Trades	Full range of products (from economic offer to best tool in market)
3	Differentiate on Application Performance and Reliability	Innovative technology, highly reliably and accurate product solutions - ease of use and rugged design
4	Strengthen Hilti's application leadership with brand shaper offerings	Gain trust and excitement within Hilti sales team. Add to and exploit trade potential

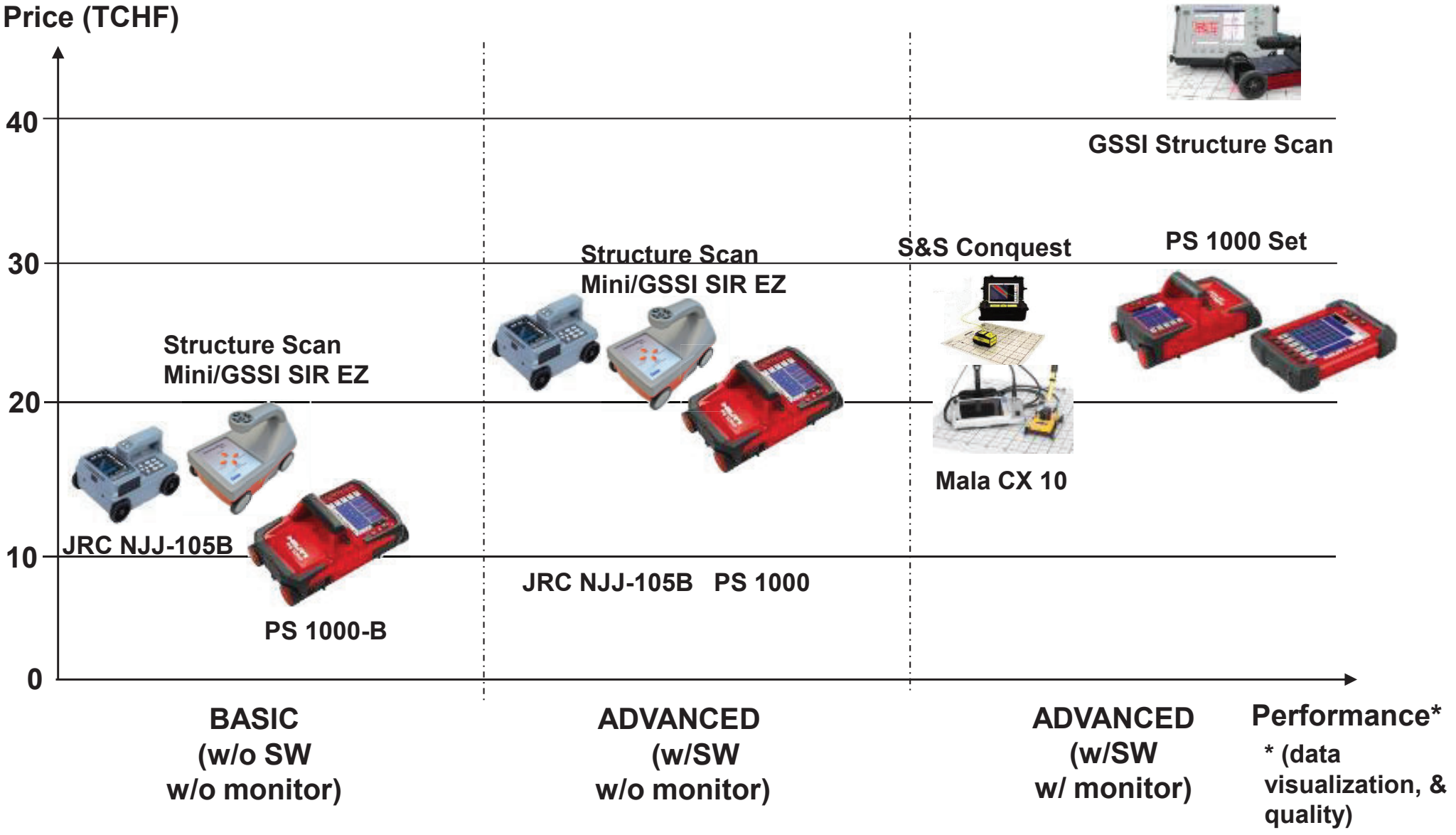
Grow Sales to >CHF 60 mio. until 2015

Market players (global view)



USRADAR INC.
PipeHawk®
Radarteam
JRC Japan Radio Co., Ltd.
Sensors & Software
MALÅ
GSSI

High differentiation paired with excellent price positioning allows to capture market share quickly



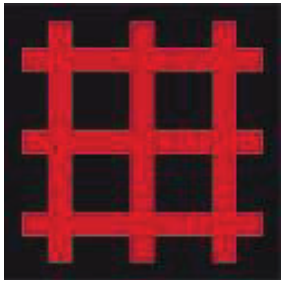
Hilti Detection Portfolio – best in class

PS 1000 X-Scan completes detection portfolio – Hilti is the only global player with range from entry to high end tools.

PS 30 Ferrodetector

New

PS 1000 X-Scan



PX 10 Transpointer

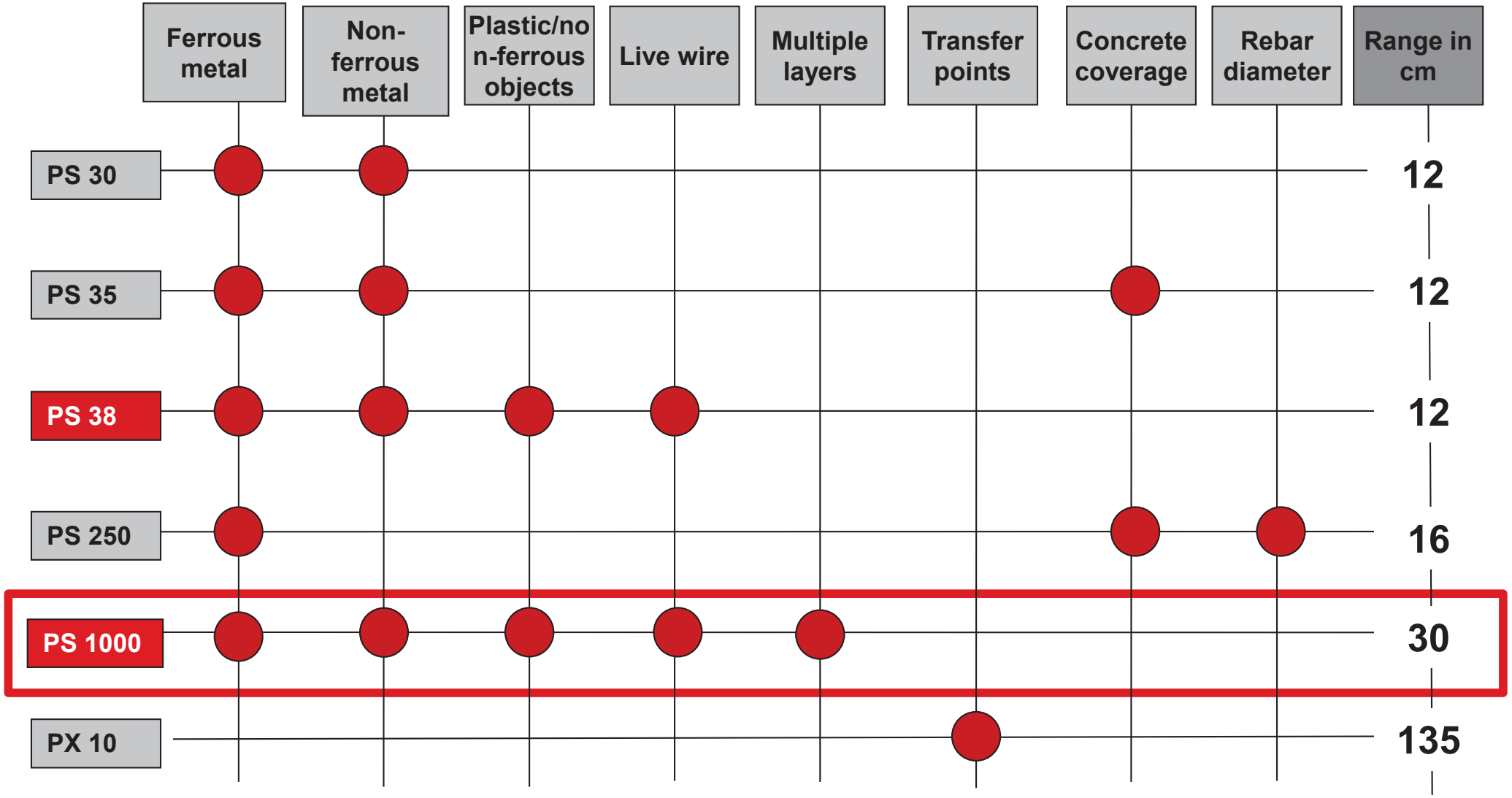
PS 35 Ferrodetector

New

PS 250 Ferroscan

PS 38 Multidetector

Product portfolio with clear application differences



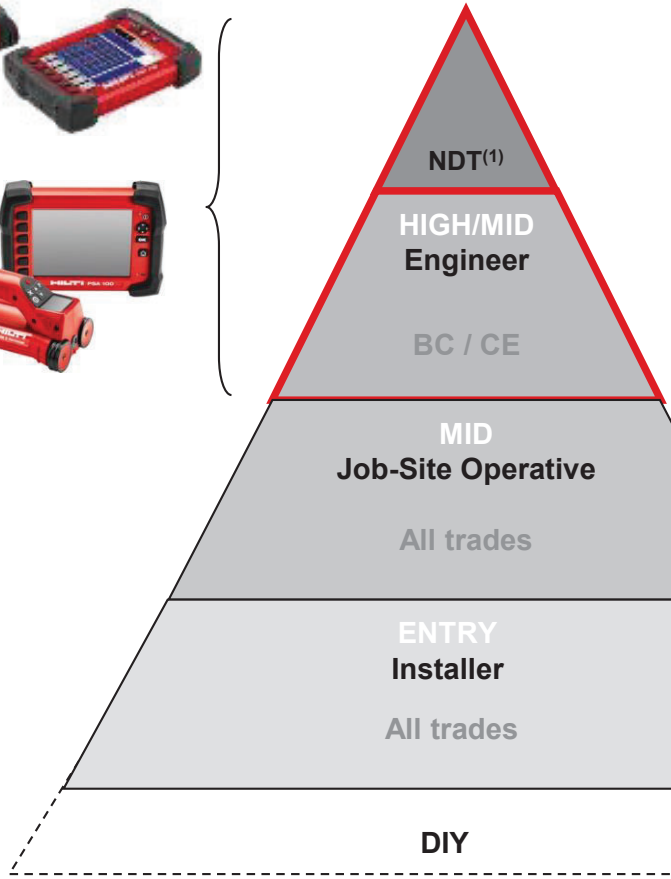
magnetic induction | pulse radar

PS 1000 X-Scan covers both detection applications (structural analysis and hit prevention)

Structural Analysis

PS 1000

PS 250



Hit Prevention

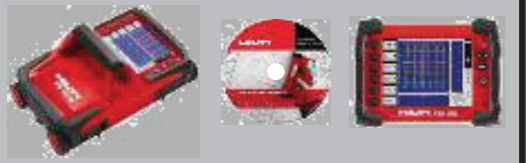
PS 1000

PS 35

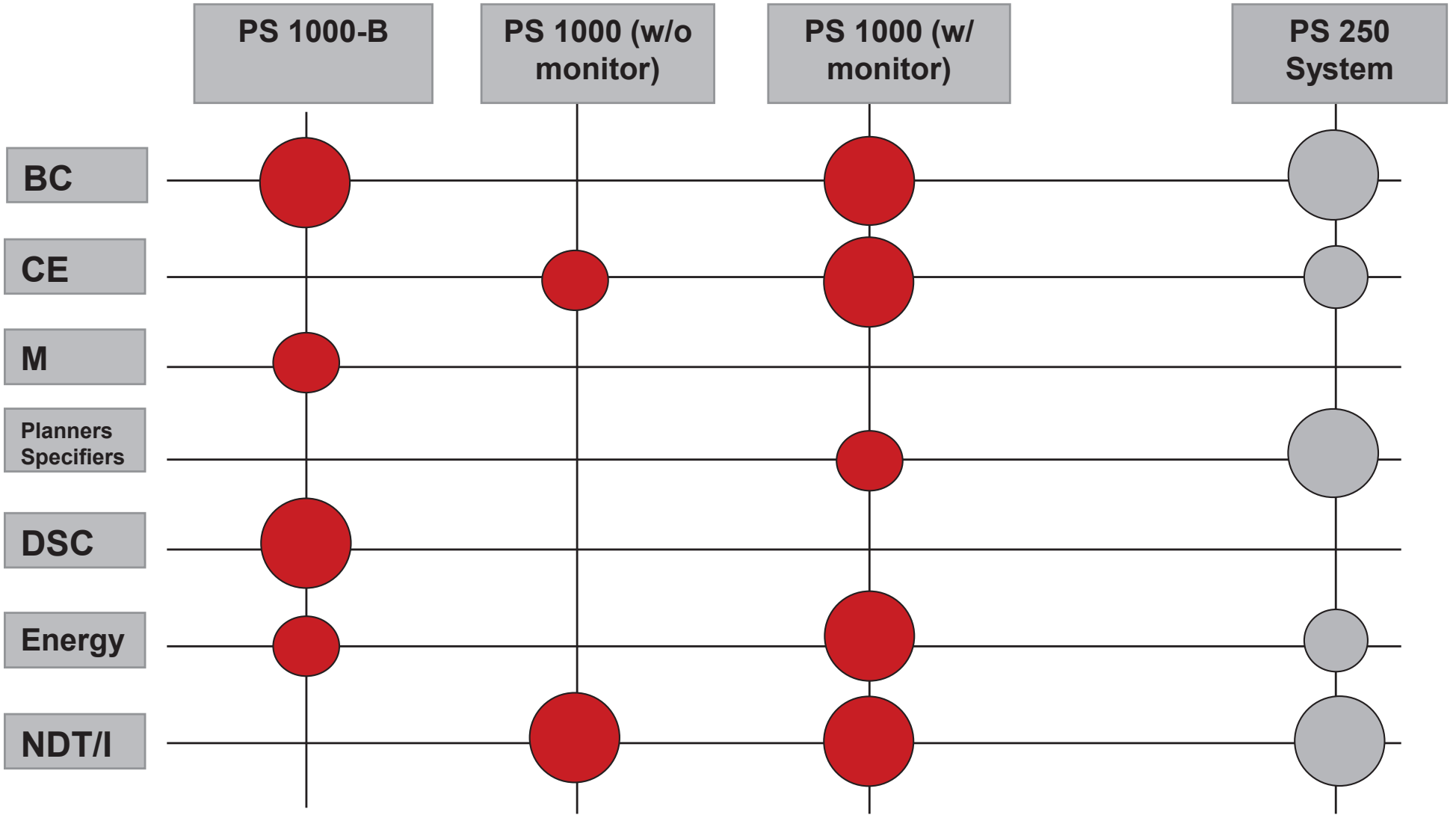
PS 38

PS 30

Product configurations for different needs

	PS 1000-B	PS 1000	PS 1000 + PSA 100
System components			
Purpose	Scanning & marking	Scanning, marking & documentation	Scanning, marking & documentation
Target customers	BC, DSC, ENERGY, I&G, M	CE, NDT/I	NDT/I, BC/CE, Energy, I & G Specifiers
Main applications	- Finding safe spots for drilling or coring - Locating objects	- Finding safe spots for drilling or coring - Structural analysis and making layout - Seismic upgrade - Locating objects	- Making layout - Structural analysis - Seismic upgrade - Finding safe spots for drilling or coring
Target ANSP* (global average)	~ 12'000 CHF	~ 20'000 CHF	~ 25'000 CHF

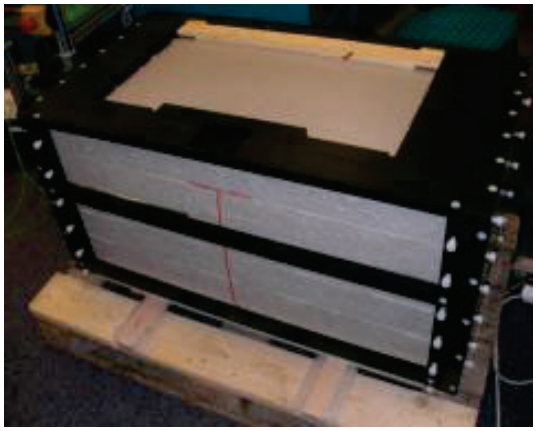
Trade segmentation



Calibration & Certification

The Hilti Calibration & Certification Service provides confirmation that a tested tool conforms with specifications given in the operating instructions.

After every calibration or repair, a calibration certificate can be issued including the tested values if requested by the customer.



PT 1000 Calibration Test Block

Note

Verification of testing results according to international / national rules can only be done by authorized institutes (accredited by government according to EAN)

Calibration includes

- checking / readjustment (all values within tool specification)
- a dated inspection plate on the tool
- a certificate with exact values of the tool as it leaves the service center

Calibration should be done by

- any Hilti Measuring Service Center
- professional personnel
- specialized calibration centers

Calibration is recommended

- at least once a year
- before especially critical jobs
- after serious dropping
- regularly for ISO certified companies

Fleet Management as unique opportunity for customers in the high end detection market

HILTI

FLEET MANAGEMENT

Hilti is the only manufacturer of detection devices which can offer fleet management to its customers.

Preserve capital - monthly expense payments instead of upfront investment

No more repair costs / free calibration and Lifetime service

Diagnostic center

For a fixed monthly fee, Hilti provides our customer with a new tool. During the usage time, there is only one monthly invoice for the tool that covers absolutely all costs (including repair). Plus -- at the end of the usage period – the fleet will be renewed with the latest generation of Hilti High end scanners.

Pay for Use

Timely Exchange

Simply No Cost

Labeling & Tracking

Theft Coverage

Loan Service

Benefits of the Hilti PS 1000 X-Scan in Fleet Management

- Hilti is the only manufacturer of detection devices which can offer fleet management to their customers.
- For many customers an initial investment of a minimum of CHF 12‘000 to max. CHF 25’000 is too high, but for a rate of several hundred CHF a month is easier to make the decision. The usage already 1x/months pays the costs instead of renting a PS 1000 X-Scan for one day or calling an expert doing an X-ray shot per drill hole. Every 2nd usage is already “for free”!
- For a fixed monthly fee, Hilti provides our customer with a new tool. During the usage time, there is only one monthly invoice for the tool that covers absolutely all costs (including repair). Plus -- at the end of the usage period – the fleet will be renewed with the latest generation of Hilti PS 1000 X-Scan.

Benefits:

- Easy accounting and cost allocation
- Preserve capital - monthly expense payments instead of upfront investment
- No more repair costs / free calibration (worth CHF 200 each)
- New tool fleet ensures you the latest innovation and technology
- Hilti Theft insurance program and service packages
- Loaner tool for peak periods, and many more…

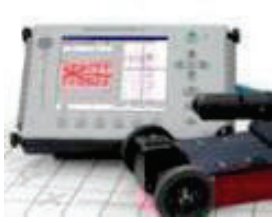
Hilti Tool Fleet Management is the right solution for PS 1000 X-Scan!

PS 1000 X-Scan
Product Training

Competition – overview

NRC
NJJ105-B

Mala CX 12



GSSI
Structure
Scan

S&S Conquest /
SL

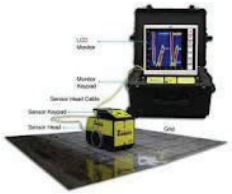
Structure Scan
Min i/ GSSI SIR-
EZ

Structure Scan
Mini HR / GSSI

There are 2 main competition groups for the PS 1000 X-Scan:

- **Big international players:** GSSI, Mala, Sensors and Software whose detection sales account for 70% of market share
- **Small national players:** US Radar, Pipehawk, JRC, IRD, Mitsui, Sweden Radar Team, Komatsu

Hilti is the clear market leader for ease of use, service and support, and availability.

	Hilti PS 1000	GSSI	Conquest/SL	JRC	Mala
					
Maximum Depth	30cm	40cm	30-60cm*	30cm	30-60cm*
Operating Time (hrs)	4hrs	2.5hrs	Not Specified	1.5hrs	6hrs
Ease of Use	☺	😐	😐	😐	😐
Service and Support	Easy to Access	Geographically Limited	Limited Access	No One Assigned Expert	Geographically Limited
Availability	Direct	Distributor	Reseller	Reseller	Distributor

Hilti PS 1000 has ticked all but one of the top 5 buying criteria. Maximum penetration depth is lacking in relation to some competitors but this sacrifice has been made to increase the resolution of the scans.

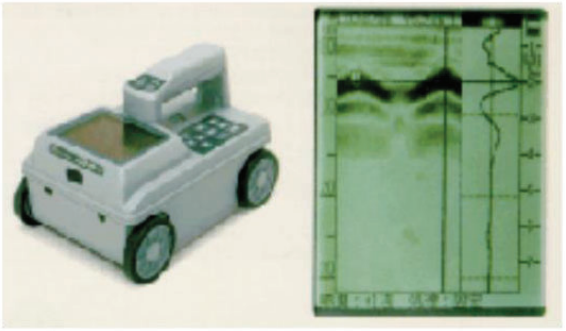
*other antenna frequency

Current product solutions are not suitable for our target group – high differentiation is required

Players

- GSSI Structurescan and Mini/EZ
- Mala CX10 and CX11
- Sensors & Software: Conquest
- JRC NJ-B
- Komatsu: Ironseeker
- US Radar: Seeker
- IDS

Mala CX 10/11 System

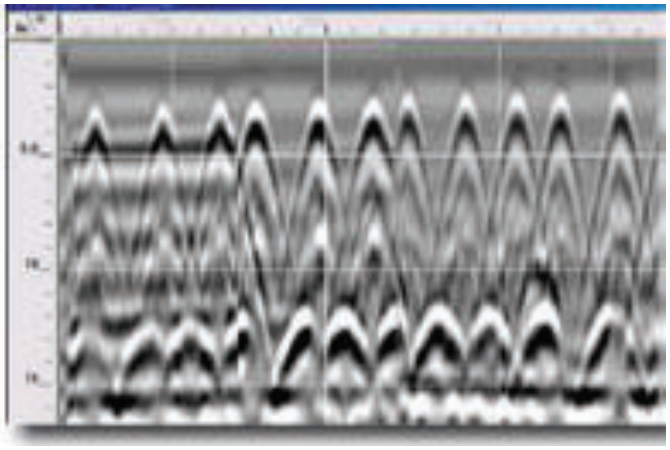


JRC unit and visualization on display for direct marking

Key findings

General impression:

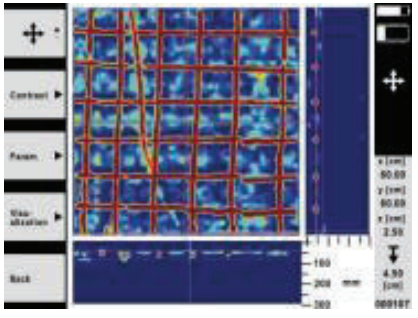
- State of the art pulse radar systems
- Expensive
- Not easy to use, complicated MMI & data visualization
- Time consuming setup
- Long measurement time
- Different antennas depending on the application

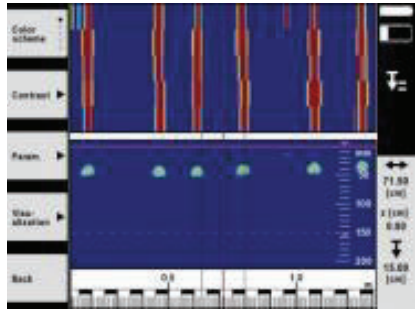


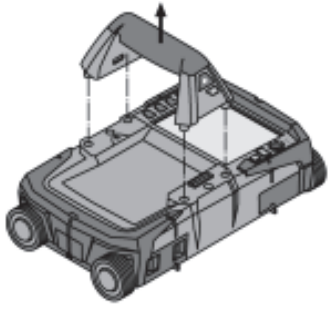
Data visualization on site

The PS 1000 offers great potential for differentiation over current market offering

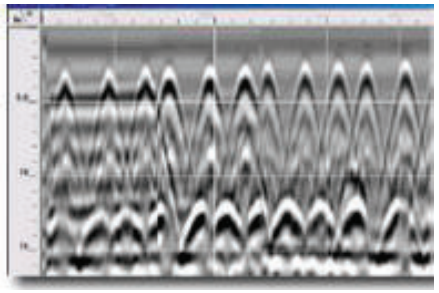
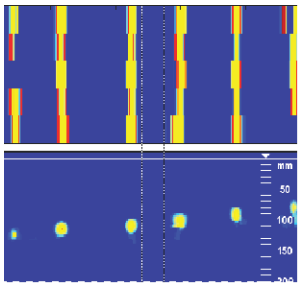
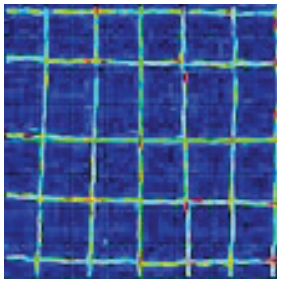
- Widely interpretation free presentation of the measured data
- High reliability and quality of data due to antenna array (redundancy of data)
- Short setup time
- Short measurement time by using an array (80% performance gain)
- Quickscan mode for easy direct layout marking
- Autonomous and robust scanner with detachable handle
- Combination with Ferroscan later possible (data overlay)
- Attractive price, good price performance ratio







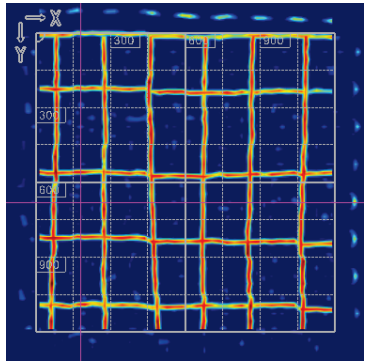
The PS 1000 X-Scan is the first easy to use radar concrete scanning system

	State of the Art – GPR(1)		PS 1000 X-Scan
System		Reduced complexity and easy set up / use	
Data		Widely interpretation-free visualization	 

The PS 1000 X-Scan is the first easy to use radar concrete scanning system

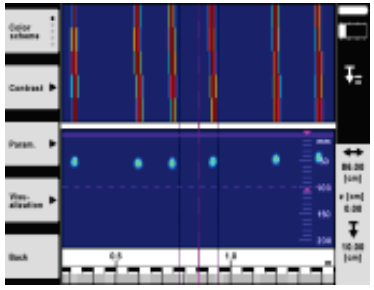
Application performance

Safe drilling / coring



- No object hits (rebar, tendon cables, live wire, plastic pipes …)
- Easy to locate objects and mark position
- Much safer solution in comparison with X-Ray
- Wireless system – self-containing scanner unit – no cables to snag

Time & cost savings / ease of use



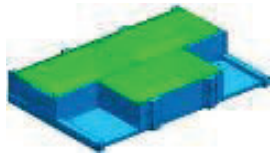
- No expert skills required
- Immediate visualization and interpretation
- Scanning efficiency for large areas due to antenna array design
- Quick and easy set up time
- Cheaper and easier solution than X-ray or GPR

Durability / Reliability

Robust design and simple MMI

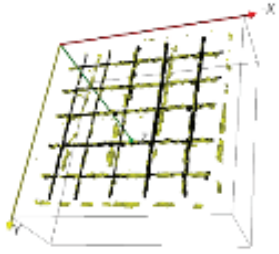
- Rugged housing
- Hand-held unit, wireless operation
- Simple MMI – two main functions
- No expert skills / less interpretation

High data quality



- Optimized for fast area visualization (no mistakes by scanning many scan lines)
- Antenna array for line and area scan – high data redundancy
- High detection reproducibility
- Low over / under detection
- Works on ferritic concrete

Data fusion



- Overlay of Ferroscan scan data for material classification and depth calibration

Tool comparison

	PS 1000 X-Scan 		GSSI Structure Scan Mini/ GSSI SIR EZ 
+	• Lower price (12TCHF/20TCHF/25TCHF) • Long operating time (4h) • Shorter scanning time for Imagescan (8/16 scan lines per grid) • 3 antennas (better performance) • Several interface languages • Top view and cross sectional view at a time in real-time (in 2D/3D) • More robust design • Detachable handle	-	• Higher price (17 TCHF/23TCHF) • Short operating time (2.5 h) • Longer scanning time (36 scan lines per grid) • One antenna • Only 3 interface languages (English, Spanish, French) • Only raw data to interprete in real time detection mode (only one view type at a time) • Space between the wheels and surface: 2 cm • Undetachable handle, scanner height
-	• Lower depth range (30 cm) • Higher weight (2.3 kg) • Bigger size • Min. wall/corner accessibility: 9.25 cm	+	• Claimed depth range: 41 cm, more data displayed but similar performance • Lower weight (1.6 kg) • Laser lines for indication the object position • Min. wall/corner accessibility: 8 cm

Key Arguments:

- **Image:** The PS 1000 X-Scan gives a real scale image, interpretation free visualization in top and cross-sectional views at a time compared to the GSSI Structure Scan Mini which gives only raw data to interprete and presents it in one view type only.
- **Performance:** The PS 1000 X-Scan scanning results are more reliable and accurate thanks to an antenna array (3).
- **Robustness:** The PS 1000 X-Scan has a more robust design.
-

Tool comparison

	PS 1000 X-Scan 		JRC NJJ 105 B 
+	• Lower price (12TCHF/20TCHF) • Long operating time (4h) • 3 antennas (better performance) • Clearer and better quality data visualization in top view and cross-sectional view • More robust design • Detachable handle • Min. wall/corner accessibility: 9.25 cm	-	• Higher price (16 TCHF/24TCHF) • Short operating time (1.5 h) • One antenna • Only raw data to interprete in real time detection • Undetachable handle (scanner height) • Data memory in scanner only for 15 m • No Imagescan mode • Cannot work under 0°C • Min. wall/corner accessibility: 10.5 cm
-	• Printing needs upload of scan to the monitor or computer • Higher weight (2.3 kg)	+	• Cableless printing (IrDA) • Lower weight (1.1 kg)

Key Arguments:

- **Image:** The PS 1000 X-Scan gives a real scale image with interpretation free visualization in top and cross-sectional views at the same time compared to the JRC NJJ 105B which gives only raw data to interprete and presents it in one view type only.
- JRC NJJ 105B offers only real time scanning modein raw data, whereas the PS 1000 X-Scan offers both: the real-time scan as well as the Imagescan mode (in 2D/3D)
- **Performance:** The PS 1000 X-Scan scanning result is more reliable and accurate thanks to the antenna array (3)

Tool comparison

	PS 1000 X-Scan 		GSSI Structure Scan 
+	• Lower price (12TCHF/20TCHF/25TCHF) • Longeoperating time (4h) • 3 antennas (better performance) • Short set up time • Shorter charging time (2 h) • Shorter scanning time for Imagescan (8 /16 scans per grid) • Clearer and better quality data visualization in top view and cross-sectional view • Cableless system for data collection • More robust design, detachable handle • EM sensor for live wire classification • Weight of the full system: 16 kg • Compact all-in-one scanning device • Ease of use • Min wall/corner accessibility: 9.25 cm	-	• Much higher price (45 TCHF) • Short operating time (3 h) • One antenna • Long set up time • Longer charging time (4-5 h) • Longer scanning time (48 scans per grid) • Only raw data to interprete for real time detection • Fixed cable between monitor and scanner • Undetachable handle • Weight of the full system: 25 kg • Separate antenna • Complex tool which is difficult to use (SW, data transfer, interpretation) • Min wall/corner accessibility: 10 cm (without cable)
-	• Protection class IP 54	+	• Max depth range 45 cm (depending on the used antenna) • Protection class IP 67 • Antenna change possible (more versatile)

Key Arguments:

- **Image:** The PS 1000 X-Scan gives a real scale image with interpretation free visualization and with top and cross-sectional views at the same time compared to the GSSI Structure Scan which gives raw data to interprete and presents it in one view type only.
- **Set up and ease of use:** The PS 1000 X-Scan has a short set-up time and way shorter scanning time for Imagescan (8 or 16 scans depending on the grid size) compared to GSSI Structure Scan which requires 48 scans per grid. The whole GSSI system consist of few parts which are connected with cables which makes it difficult to use (especially on walls/ceilings)
- **Price:** The GSSI Structure Scan costs double the price of the PS 1000 X-Scan

Tool comparison

	PS 1000 X-Scan 		Mala CX 11 
+	• 3 antennas (better performance) • Short charging time (2 h) • Short set up time • Shorter scanning time for Imagescan (8/16 scans per grid) • Clearer and better quality data visualization in top view and cross-sectional view • Cableless system for data collection • Detachable handle • Weight of the full system: 16 kg • Easy to use • Robust design • Compact all-in-one scanning device • Min wall/corner accessibility: 9.25 cm	-	• One antenna • Long charging time (5 h) • Long set up time • Longer scanning time for Imagescan (32 scans per grid) • Only raw data to interprete for real time detection • Fixed cable between monitor and scanner • Undetachable handle • Weight of the full system: 20 kg • Complex tool with many parts, which is difficult to use • Without a plastic cart – very complicated to record exact data • SW difficult to use • Min. wall/corner accessibility: 10 cm (without a cable)
-	• Higher price (25 TCHF) • Shorter operating time (4 h) • Smaller display on monitor (8.5 in)	+	• Lower price (20 TCHF) • Longer operating time (6 h) • Bigger display in monitor (10.4 in) • Antenna change possible (more versatile)

Key Arguments:

- **Image:** The PS 1000 X-Scan gives a real scale image with interpretation free visualization and with top and cross-sectional views at the same time compared to the Mala CX 11 which gives raw data to interprete and presents it in one view type only.
- **Set up and ease of use:** The PS 1000 X-Scan has a short set-up time and way shorter scanning time for Imagescan (8 or 16 scans depending on the grid size) compared to the Mala CX 11 which requires 32 scans per grid. The whole Mala system consist of few parts which are connected with cables which makes it difficult to use (especially on walls/ceilings).

Value proposition PS 1000: easy, reliable and rugged for best performance in most applications

Easy

- Easy to use: compact handheld scanner with efficient scanning for large areas
- Easy to interpret data: 2D/3D, top view and cross sectional view
- Easy and fast set up

Reliable

- Detects all kind of objects up to 30 cm
- Antenna array (3 antenna) provides better performance and data quality
- PC software and Monitor provides images for evaluation and documentation

Rugged

- IP 54 protection
- Rubber coated for better jobsite fit

Outperform | **Outlast**

Hilti Fleet Management, Hilti Lifetime Service, Hilti Calibration Service

Value Proposition of PS 1000 X-Scan

Construction Trends	• Time pressure • Cost pressure • Convenience	• Shortage skilled labor • Quality • Health & Safety	Non-destructive testing
Customer Needs	• **High performance / detection reliability:** reliable results (low over- or under detection rate; all objects embedded in structures located • **Safe working:** Drilling/coring without potential hits; safer, cheaper and easier solution versus X-Ray; • **Ease of use:** no expert skills required; easy and quick set up		
Value Prop. PS 1000	*Save Money* | *Save Time* Ease of use in application	Robustness & Durability	

• **Detection reliability**	Reliable results (low under or over detection, high reproducibility); data redundancy due to antenna array
• **High performance**	Interpretation free visualization of objects embedded in structures; allows to scan large areas; data fusion with Ferroscan (calibration, material classification)
• **Safe working**	Drilling/coring without potential hits; safer solution versus X-Ray; wireless system
• **Ease of use**	No expert skills required; easy set up
• **Time & cost savings**	Scanning efficiency for large areas (inspect or serial drilling applications; quick set up time; immediate visualization / interpretation of scan results on site; safer, cheaper and easier solution vs. X-Ray (1 scan / month with FM is cheaper than calling X-ray specialist for scan)

Why should mainstream customers use a detection tool over hiring a specialist or simply rely on plans?

Customers drilling / coring

Ease of use:	No expert skills required – interpretation free visualization of objects embedded in structures; easy and quick set up
Time & cost savings:	Scanning efficiency for serial drilling applications; immediate visualization / marking of objects possible; safer, cheaper and easier solution vs. calling in an expert
Safe working:	Drilling/coring without potential hits; safer, cheaper and easier solution versus blind drilling, X-ray, …
High performance / detection reliability:	Reliable results (low under or over detection, high reproducibility)

Drilling made easy – one object hit avoided pays the tool!

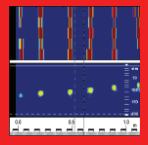
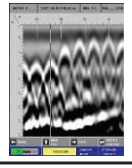
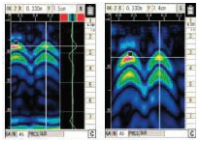
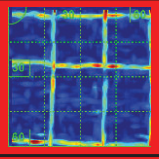
Why should expert customers work with our detection tool over competitor's?

Detection specialists / Engineers

High performance / detection reliability:	Interpretation free visualization; allows to scan large areas conveniently; Reliable results (low under or over detection, high reproducibility); data redundancy due to antenna array; data fusion with Ferroscan (calibration, material classification)
Ease of use:	Easy and quick set up; suitable for first quick analysis prior to advanced analysis; self containing scanner – wireless, small, ideal also for wall & ceiling applications
Safe working:	Safer, cheaper and easier solution versus X-ray, …; working on walls/ceilings easier with scanner unit only;
Time & cost savings:	Scanning efficiency for large areas (5x faster); quick set up time (5x faster); immediate visualization / interpretation of scan results on site; safer, cheaper and easier solution vs. X-Ray

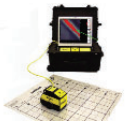
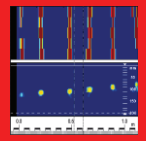
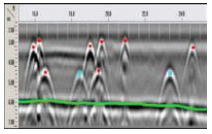
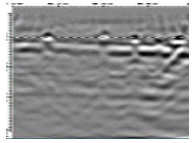
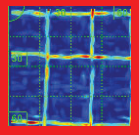
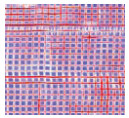
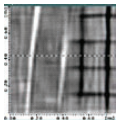
The best and easiest detection system for the majority of applications with unmatched visualization capabilities

Competitors analysis for PS 1000-B/PS 1000

Brand		Hilti	GSSI	JRC
Model		PS 1000-B/PS 1000	Structure Scan Mini/GSSI SIR-EZ	NJJ-105B
Picture				
Results Sample	Line Scan			
	Image Scan			
System Components		Scanner	Scanner + PC software (optional)	Scanner + PC software (optional)
Price estimation (CHF)*		12,000 (20,000 w/PC SW)	17,000 (23,000 w/PC SW)	16'000 (24'000 w/ PC SW)
General Specifications				
Max. depth range (cm)		30	41	30
Operating time (hours)		4	2.5	1.5
Charge time (hours)		2	?	2.5
Antenna frequency (GHz)		1 to 4.3	1.6	0.7
Data memory		10 scans	-	512 MB (200 Scans of 15m)
Display size (inch)		5.7	5.7	?
Other specifications				
Operating temperature (°C)		-15 to 50	-10 to 41	0 to 50
Storage temperature (°C)		-25 to 63	-	-
Dimensions (mm)		318x190x143	152x178x230	149x147x216
Weight (kg)		2.3	1.6	1.1
Protection		IP 54	IP 64	IP 54

*Global average price

Competitors analysis for PS 1000-B/PS 1000

Brand		Hilti	GSSI	Mala	S&S
Model		**PS 1000**	**Structure Scan**	**CX 11**	Conquest
Picture					
Results Sample	**Line Scan**				
	Image Scan				
System Components		Scanner + PC SW + Monitor (optional)	Scanner + computer + antenna + PC SW	Scanner + computer + antenna + PC SW	Scanner + computer + antenna + PC SW
Price estimation (CHF)*		25,000	**45,000**	**20,000**	**25,000**
General Specifications					
Max. depth range (cm)		30	45	30	60
Operating time (hours)		4	3	6	?
Charge time (hours)		2	4-5	5	?
Antenna frequency (GHz)		1 to 4.3	1.6 or 2.6	1.2, 1.6 or 2.3	1
Data memory		10 scans	2 GB	1 GB	?
Display size (inch)		5.7	8.4	10.4	17
Grid sizes (mm)		600 x 600, 1200 x 1200	300 x 600	800x800	600 x 600, 1200 x 1200
Number of scans per grid		8 & 16	48	32	12 & 24
Relation between components		Removable cable	Fixed cable	Fixed cable	Fixed cable
EM Sensor		Yes, integrated	no	Yes (optional antenna)	Yes, integrated
Other specifications					
Operating temperature (°C)		-15 to 50	-10 to 40	-20 to 50	-20 to 45
Storage temperature (°C)		-25 to 63	-	-	-
Dimensions (mm)		318x190x143	315 x 220 x 105	410 x 210 x 55	300 x 150 x 110
Weight (kg)		2.3	4.1 (25 full system)	3.5 (20 full system)	2.3 (21.1 full system)
Protection		IP 54	IP 67	IP 67	IP 67

*Global average price

PS 1000 X-Scan
Product Training

PS 1000 X-Scan

5 Buttons:

- easy user interface
- navigation with hard/softkeys and joystick

Start/stop/cancel button

Robust design

Marking notch

Status LED

Interface connections

Joystick

Home button / operating manual

Marking notches

Battery compartment

Cable interface

Product Benefits: Scanner

State of the art technology. Hand held tool. Quick and easy to set up and operate. Different scan modes for different needs.

1. Turn the tool on.

→ QUICK AND EASY TO SET UP

2. Press the Settings button on the left and adjust Brightness, Volume, Date/Time, Power Settings and Language if needed.

→ EASY TO OPERATE AND NAVIGATE

3. Select scan mode: Quickscan, Quickscan Recording, Imagescan or choose one of the previous recorded scans in Projects in order to analyze it.

→ DIFFERENT MODES FOR DIFFERENT NEEDS, QUICK SCANNING, RELIABLE AND ACCURATE RESULTS

PSA 100 Monitor

Interface connections

Data transfer, head set

6 Buttons:

- easy user interface
- navigation with hard/softkeys and joystick

Status LED's

Joystick

Home button

Battery compartment

Robust design

Product Benefits: PSA 100 Monitor

Analyzing scanning results in 2D and 3D, setting markers and creating documentation with the Hilti PSA 100 Monitor

Analyze results in 3D

Adjust parameters and visualization to your needs

Make decisions based on the analysis (drilling, coring) and enter markers to the project.

Create documentation

Easy set-up

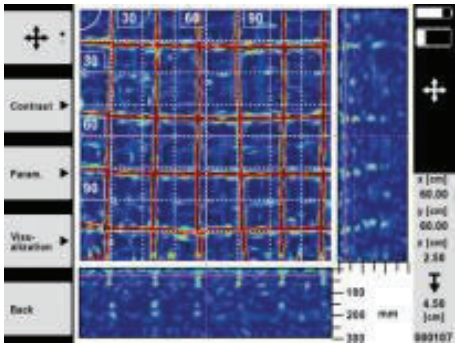
Easy navigation and monitor operation

Home button with operating manual

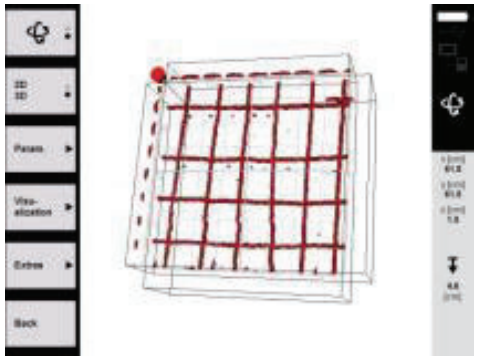
1. Turn the Monitor PSA 100 on. Accept the disclaimer.
2. Transfer data from PS 1000 X-Scan to the Monitor by PSA 50 data transfer cable .
3. Open a scan within a project. It will be presented in 2D top view. Adjust settings: “contrast“ of the results shown, parameter “concrete “, depth range and visualization parameters. Use joystick buttons to make changes.
4. Press the 2D/3D button in order to see the scanning results in 3 D. Adjust settings if needed.
5. Set depth markers, drill hole markers in the scan or create a preview icon or a pdf file by exporting to the USB stick.

Product Benefits: PSA 100 Monitor

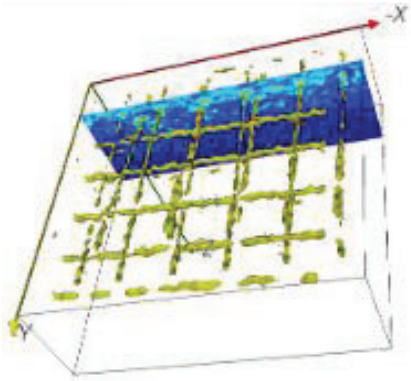
1. Enhanced scan analysis: calibration and 2D/3D view



2D view

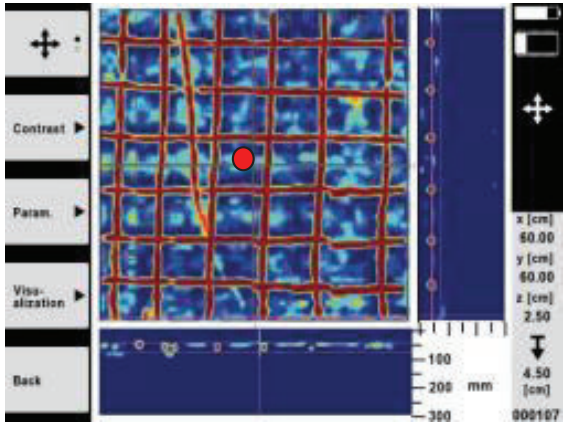


3D view



cross section cut

2. Onsite documentation: drill markers and printing options

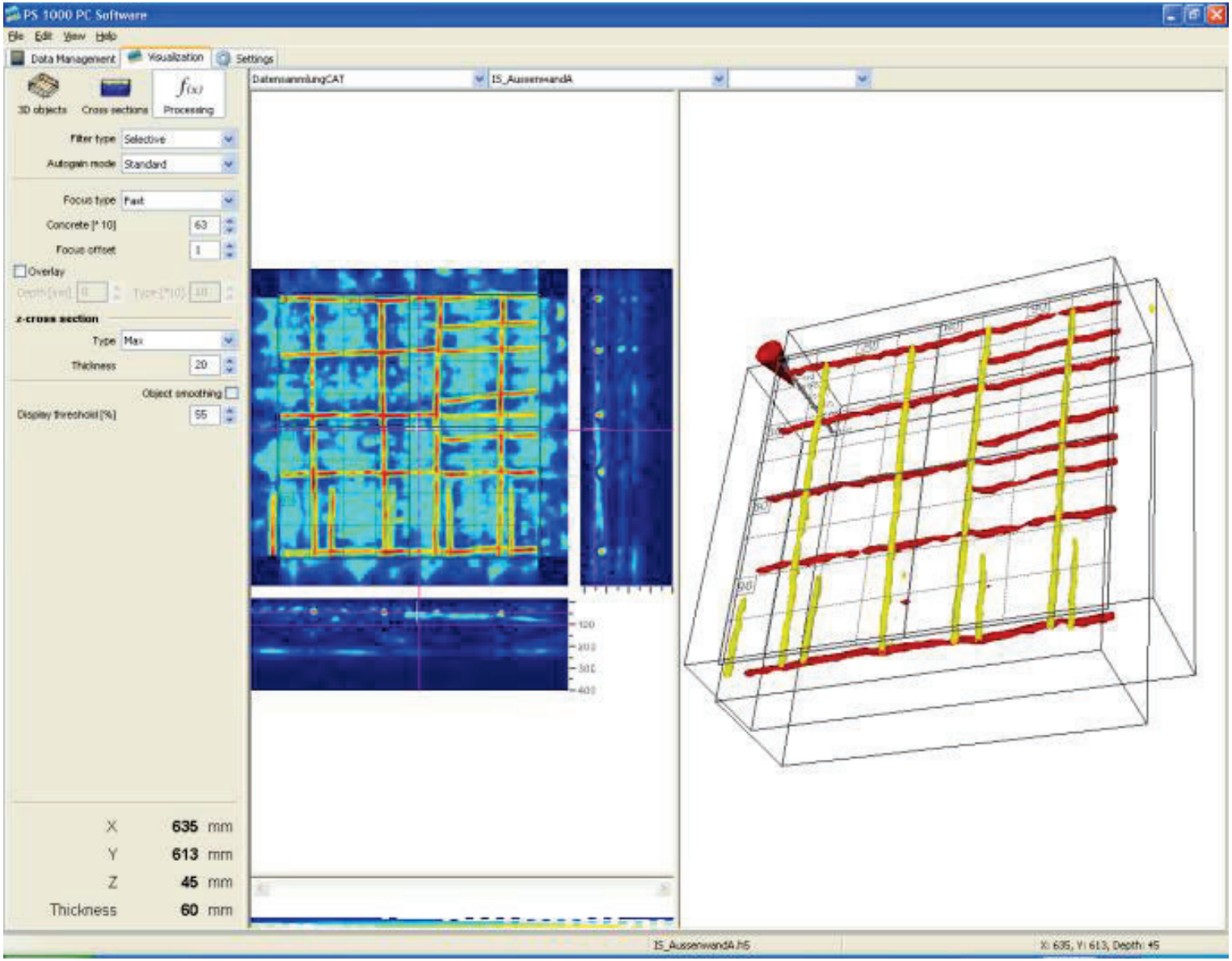


3. Data management and reporting

4. Accessoires

Product Benefits: PROFIS PS 1000 Software

1. Data management
2. Enhanced scan analysis
3. Reporting



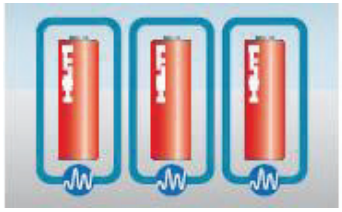
Product Benefits: PSA 81 Li-Ion Battery pack

100% working power always with the Hilti PSA 81 Li-Ion battery pack

PSA 81 (scanner)

Charging plug

Connect to the PUA 81 mains adapter for charging



Individual cell voltage control
The Hilti Lithium CPC system monitors each cell electronically, which is essential for long battery life.

Long-life cells
The rugged 3.6 V cells in these Hilti batteries guarantee a higher number of charging cycles and thus longer total battery lifetime.

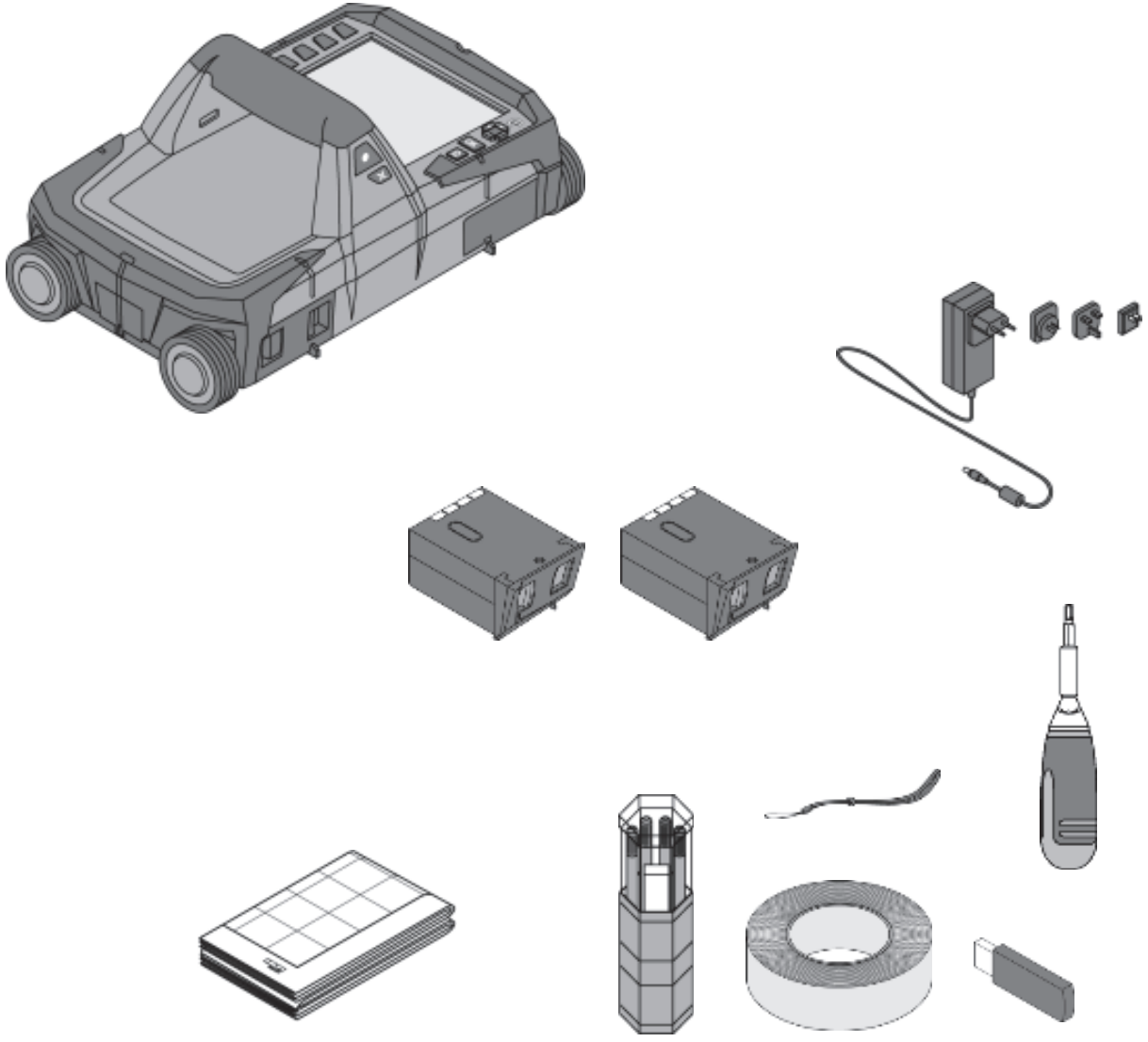
State of charge and warning LEDs
Hilti Lithium CPC batteries feature an LED charge status display. You can therefore check the level of the “fuel tank” at any time.

Glass-fiber reinforced
Exceptionally ruggedly built to withstand the harsh conditions of everyday jobsite use, Hilti Lithium CPC batteries and tools feature tough fiberglass-reinforced casings with rubber grip areas.

Advantages of Lithium-ion:

- More work per battery charge – up to 100% higher capacity than NiCd/NiMh batteries of the same weight
- Ready to use in no time – very fast initial charge to 75% capacity
- Less weight – only half the weight of NiCd/NiMh batteries of the same capacity
- No self-discharge – batteries don’t lose their charge during storage and are ready to use at any time
- Environmentally friendly – in contrast to NiCd batteries, no pollution by heavy metals

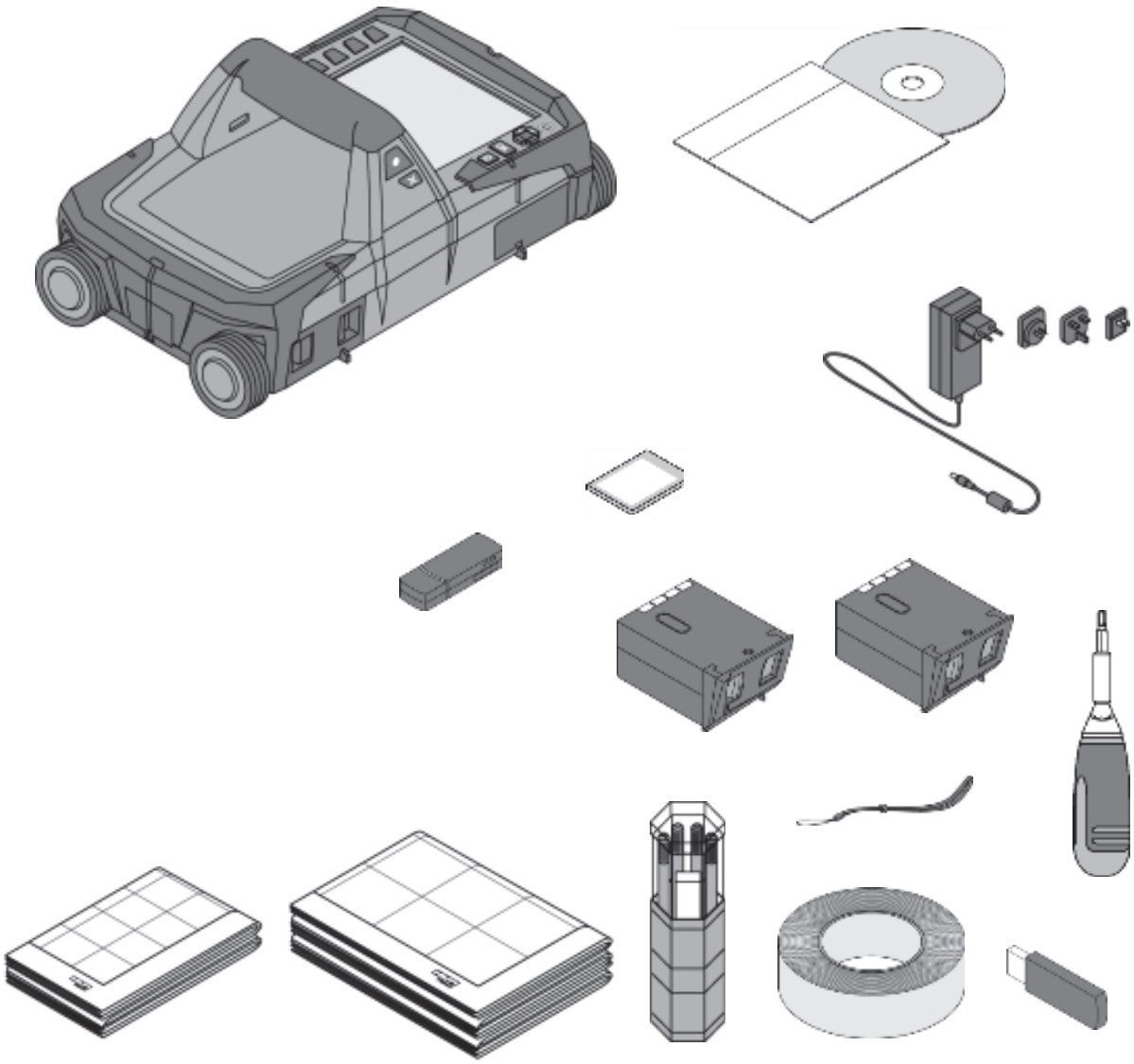
PS 1000-B Sales Package



- 1 PS 1000-B X-Scan

- 1 PUA 81 mains adapter
- 2 PSA 81 battery packs
- 5 PSA 12/13 reference grids
- 1 PSA 97 data module USB
- 1 PUA 70 markers box
- 1 PUA 90 adhesive tape
- 1 PSA 75 brush
- 1 PSA 63 hand strap
- 1 PSW 1000-3 torch wrench
- 1 Producer certificate
- 2 operating instructions
- 1 Hilti box

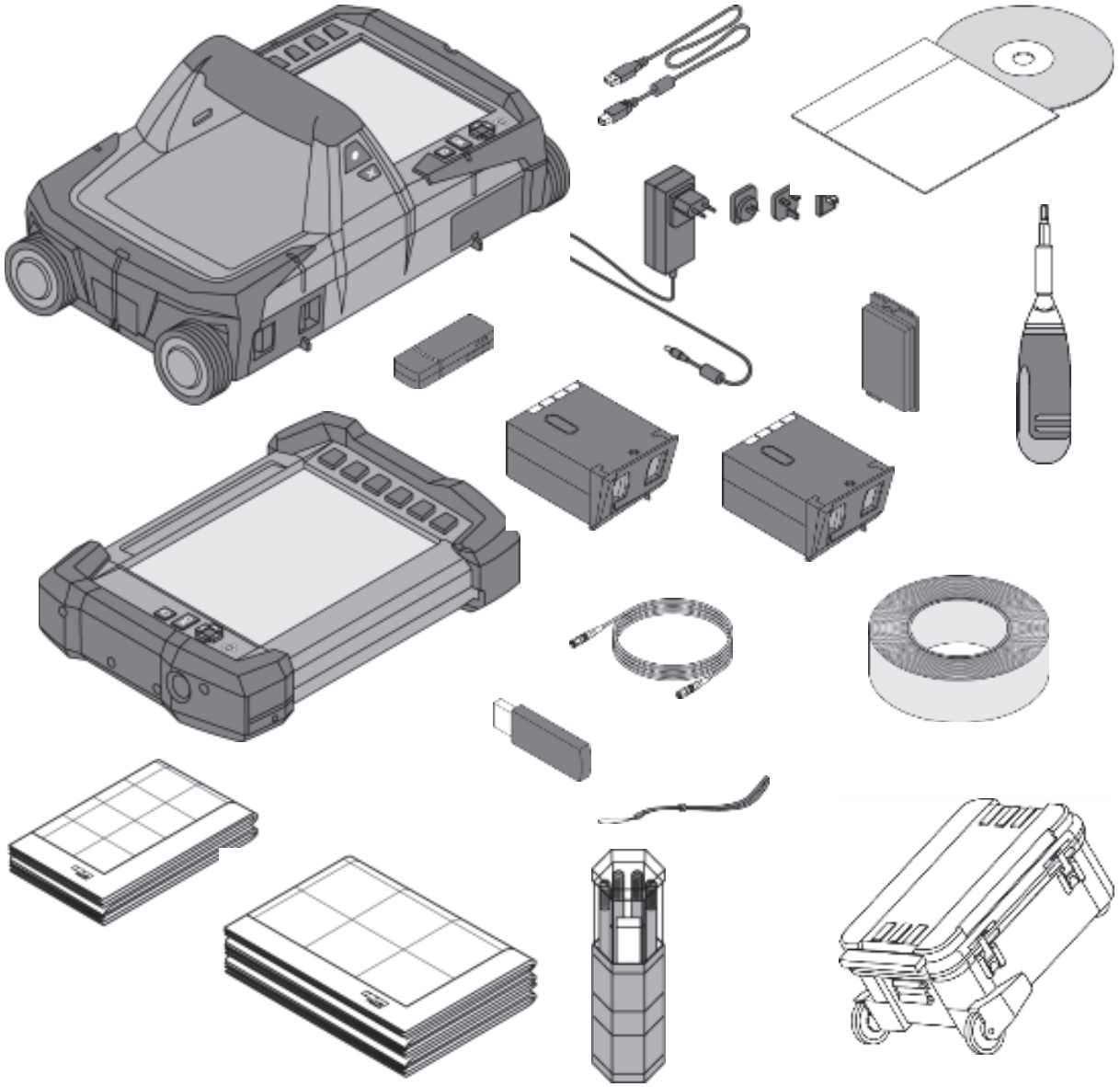
PS 1000 Sales Package



- 1 PS 1000 X-Scan
- 1 PROFIS PS 1000

- 1 PUA 81 mains adapter
- 2 PSA 81 battery packs
- 5 PSA 12/13 reference grids
- 2 PSA 14/15 reference grids
- 1 PSA 97 data module USB
- 1 PSA 95 memory card
- 1 PSA 96 adapter
- 1 PSA 75 brush
- 1 PUA 70 markers
- 1 PUA 90 adhesive tape
- 1 PSA 63 hand strap
- 1 PSW 1000-3 torch wrench
- 1 Producer certificate
- 2 operating instructions
- 1 Hilti box

PS 1000 System Sales Package



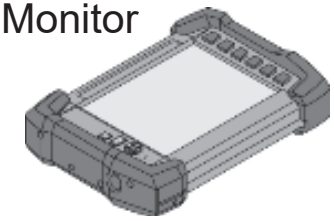
- 1 PS 1000 X-Scan
- 1 PROFIS PS 1000
- 1 PSA 100 Monitor

- 1 PUA 81 mains adapter
- 2 PSA 81 battery packs
- 5 PSA 12/13 reference grids
- 2 PSA 14/15 reference grids
- 1 PSA 92 data cable USB
- 1 PSA 82 battery pack
- 1 PSA 93 headset
- 1 PSA 50 connecting cable
- 1 PSA 97 data module
- 1 PSA 96 adapter
- 1 PUA 70 markers box
- 1 PUA 90 adhesive tape
- 1 PSA 63 hand strap
- 1 PSW 1000-3 Torch wrench
- 1 PSA 75 brush
- 1 Producer certificate
- 3 operating instructions
- 1 Hilti trolley

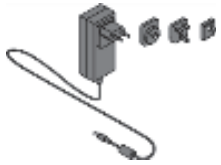
System Overview

The PS 1000 X-Scan is completed by rugged, simple and versatile accessories making it an unbeatable system!

PSA 100
Monitor



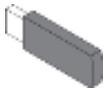
PSA 81
Battery pack



PUA 81 Mains
adapter

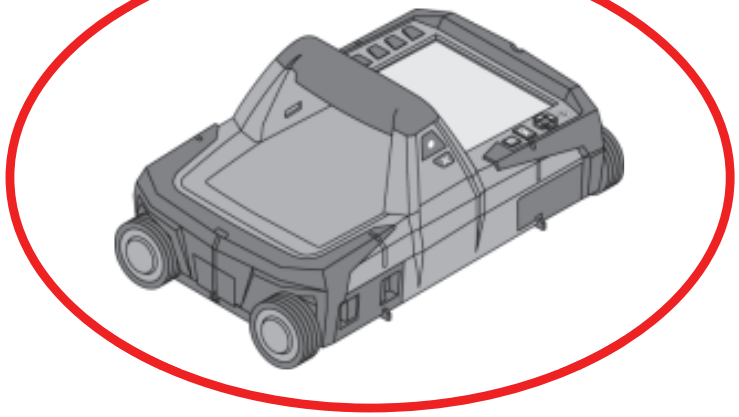
PSA 82
Battery pack

PSA 75 brush

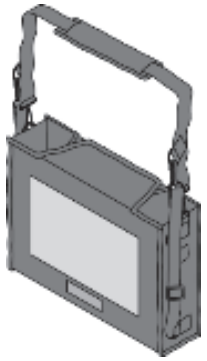


PSA 97 Data
module

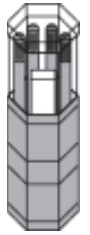
PSA 93
Head set



PSA 92 Data
cable USB



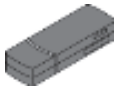
PSA 95
Memory card



PUA 70
Markers box

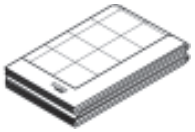
PSA 50
Connecting cable

PSA 64
Monitor
pouch

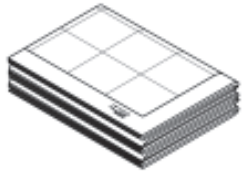


PSA 96
Adapter

PSA 68 Hand
Strap

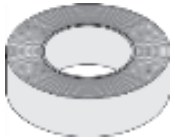


PSA 12/13
Reference grid



PSA 14/15
Reference grid

PUA 90
Adhesive tape



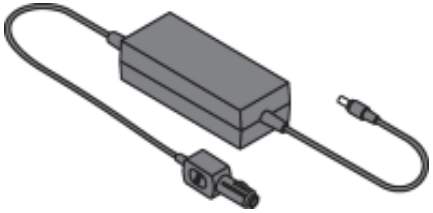
PROFIS
Software

Additional accessories to PS 1000 System

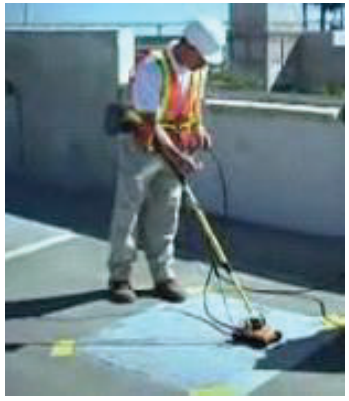
PSA 85 battery charger (monitor)

PSA 51 connecting cable (10 m)

PUA 82 Car battery plug



PSA 65 carrying device



PSA 70 extension

Technical data PS 1000 X-Scan

Max. detection range for object location	300 mm (dependent on object spacing, size and type of object, base material type and condition
Location accuracy (standard)	+/- 10 mm (+/- 1% of length)
Location accuracy (max)	+/- 5 mm
Min. distance between two neighbouring objects	40 mm
Accuracy of depth measurement	< 100 mm: +/-10 mm > 100 mm: +/-15%
Remark about accuracy of depth measurement	dependent on depth, size and type of object, base material type and condition; concrete parameter setting
Accuracy distance measurement	1%
Radar frequency range	1.0 -4.3 GHz (-10 dB)
Radar center frequency	2.0 GHz
EM Sensor sensitivity	double wire (d = 5 mm) in 8 cm depth with I = 250 mA (45 - 65 Hz)
Max. scanning speed	0.5 m/sec.
Min. scan length	320 mm
Max. scan length	10 m
Display type	TFT 5.7 "
Display resolution	640x480 pixel
Display color quality	256 colors
Display width x display height	115x86 mm
Memory capacity	approx. 200 Scans (SD), approx. 10 scans (internal flash memory)
Data memory	SD-card, internal flash memory
Operation time with Li-Ion battery pack	4 h
Automatic power-off	configurable
Scanner dimensions (length x width x height)	318x190x143 mm
Scanner weight	2.45 kg
Operating temperature	-10 -+50°C
Storage temperature	-25 -+63°C
Max. relative humidity	95% @ 40°C
IP protection class	IP 54

Technical data: PSA 100

Display type	LCD 8 "
Display resolution	800 x 600 pixel
Display color quality	true colors, 32 bit
Display width x height	173 x 130 mm
Memory capacity	approx. 500 Imagescans 8x8 or 2000 Imagescans 4x4 or 11500 Quickscans
Scanner - monitor data interface	Ethernet 100 Mbit/s
Operation time with Li-Ion battery pack	2h
Automatic power-off	configurable
Dimensions (length x width x height)	292 x 208 x 65 mm
Weight	2.26 kg
Operating temperature	-15 -+50°C
Storage temperature	-25 -+63°C
Max. relative humidity	95% @ 40°C
IP protection class	IP 54

PS 1000 X-Scan
Product Training

Application overview by trade

Customers according to trades

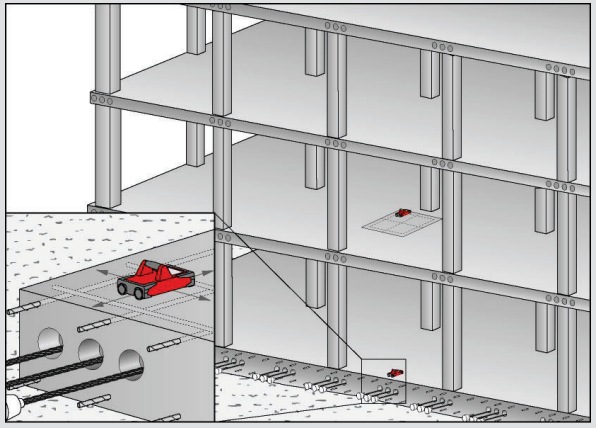
Applications

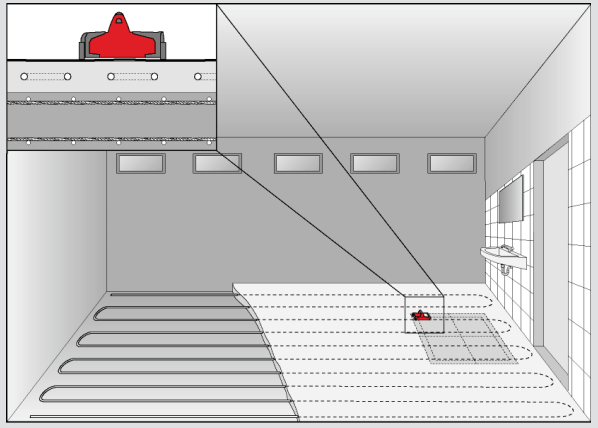
Application	BC	M&E	SM	Utility/Maint/Indust	CE	DSC	Gov	NDT
Localization in concrete of Rebars Tendons Metal and plastic conduits Glass fiber cables Electrical conduits	✓	✓			✓		✓	✓
Rebar extension for the load-bearing construction	✓				✓		✓	✓
Hit prevention for anchoring and through drillings, diamond coring and break outs and diamond sawing applications	✓	✓	✓	✓	✓	✓	✓	✓
Quality assessment of the layout of rebars and tendons (e.g. curvature, density, depth)	⋰				✓		✓	✓

Main applications per trade

BC

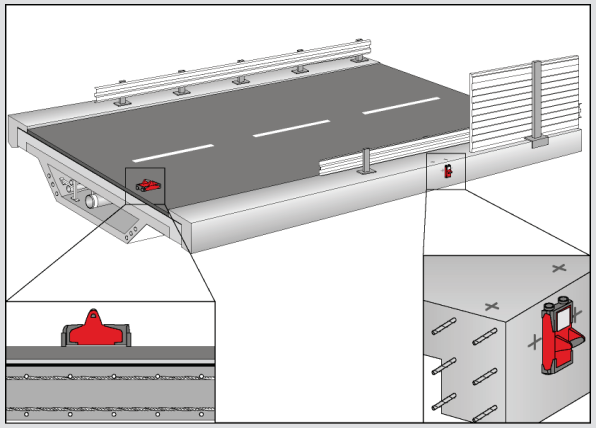
- Finding safe spots for drilling or coring in embedded objects e.g. PT decks
- Location of floor heating
- Structural analysis
- Seismic upgrade
- Checking stab thickness

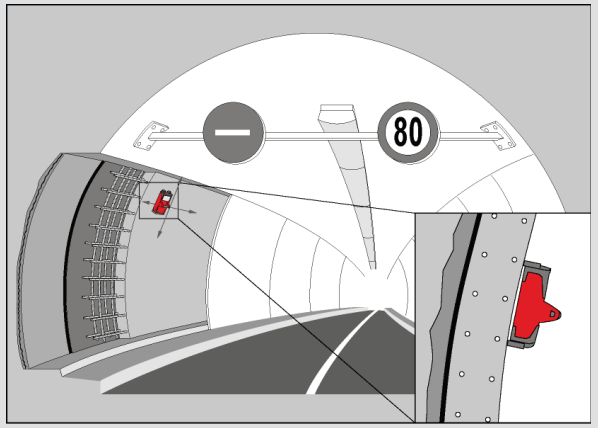




CE

- Non destructive testing on bridges or tunnels
- Location of tendon cables and rebar mesh
- Structural analysis
- Seismic upgrade
- Checking concrete thickness
- Finding safe spots for drilling or coring

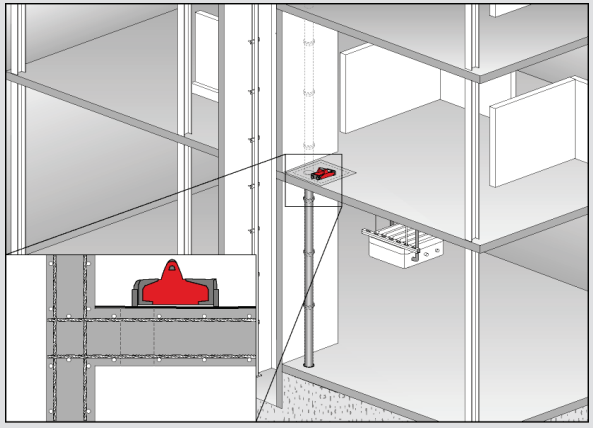


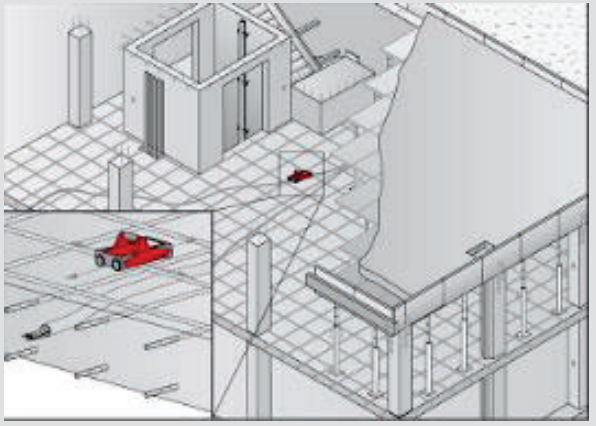


Main applications per trade

DSC

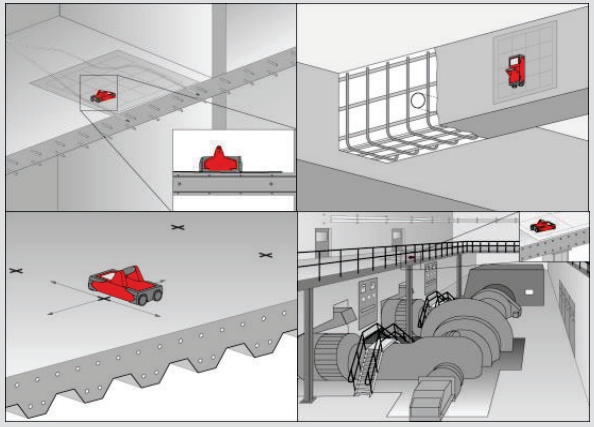
- Finding safe spots for drilling, coring sawing

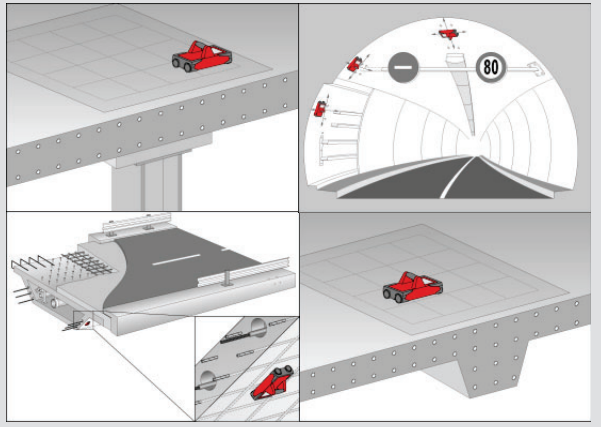




NTD / I

- All kinds of Non Destructive Testing and Inspection for making layout

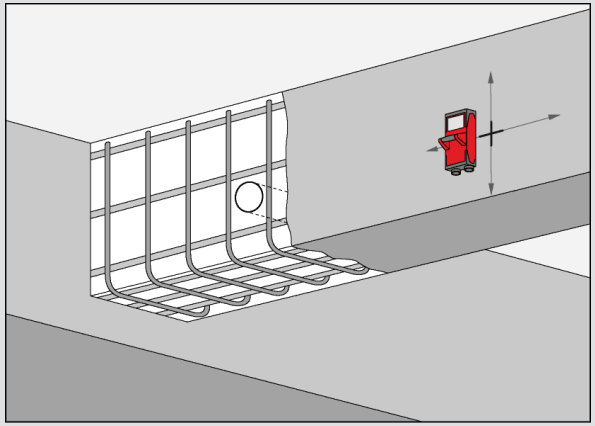


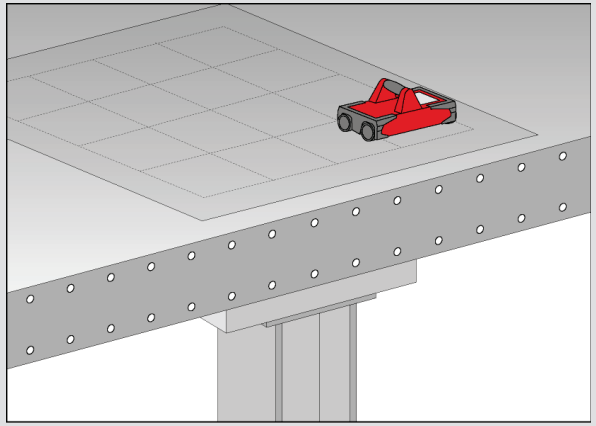


Main applications per trade 3/3

I & G

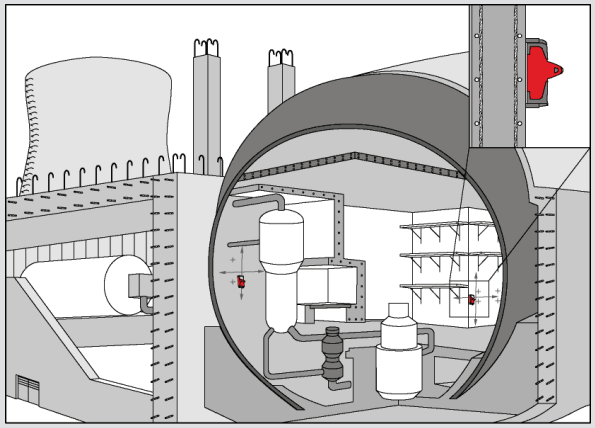
- Finding safe spots for drilling / coring in floors, walls or beams to avoid rebar, tendon cables, electrical conduit
- Structural analysis
- 3D modelling (as-built)

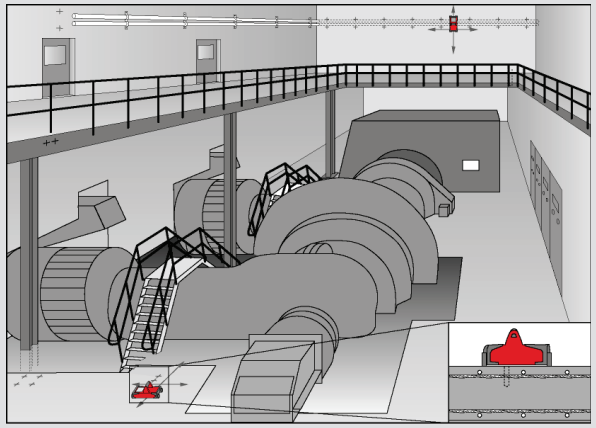




Energy

- Non Destructive Testing
- Structural analysis
- Avoid object hits in heavily reinforced structures
- Seismic upgrade
- 3D modelling (as-built)





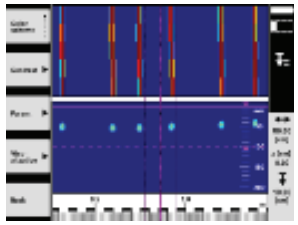
Tailored functionalities for different needs packed in two different tool concepts

Scan modes are adapted to the product concepts regarding main customer applications!

PS 1000-B

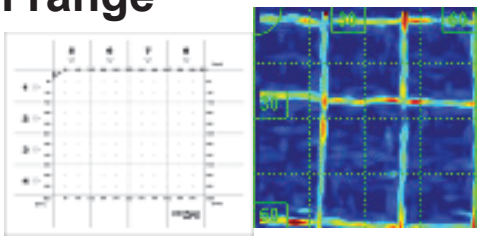
Quickscan Detection

One axis real time scan up to 30 cm depth range (for direct marking)



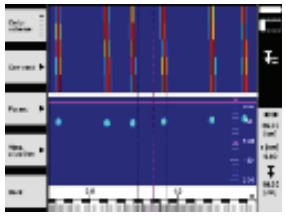
Imagescan standard (600x600 mm)

Two axis area scan up to 30 cm depth range



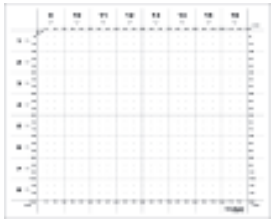
Quickscan Recording

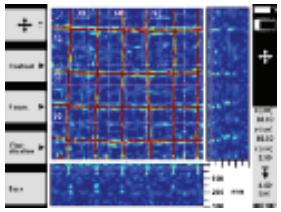
One axis recorded scan up to 30 cm depth range (10m max)



Imagescan (1200x1200mm)

Two axis area scan up to 30 cm depth range





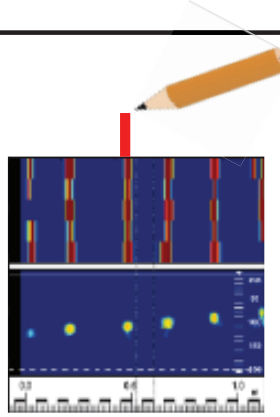
PS 1000

Quickscan Detection and Recording

One dimensional scan

Detection

- Detection
  - real time scan result for direct marking
  - depth range 30 cm
  - depth indication



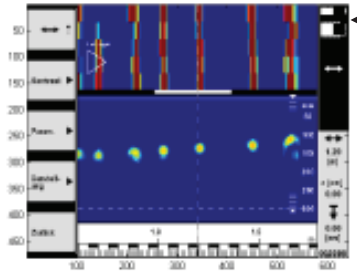
Top view
Cross view
Depth indication
Distance indication

Recording

- Recording – data recorded in memory
  - depth range 30 cm
  - max. scan length 10 m
  - depth indication

Scan direction
Recording sign
Distance covered

- Analysing results

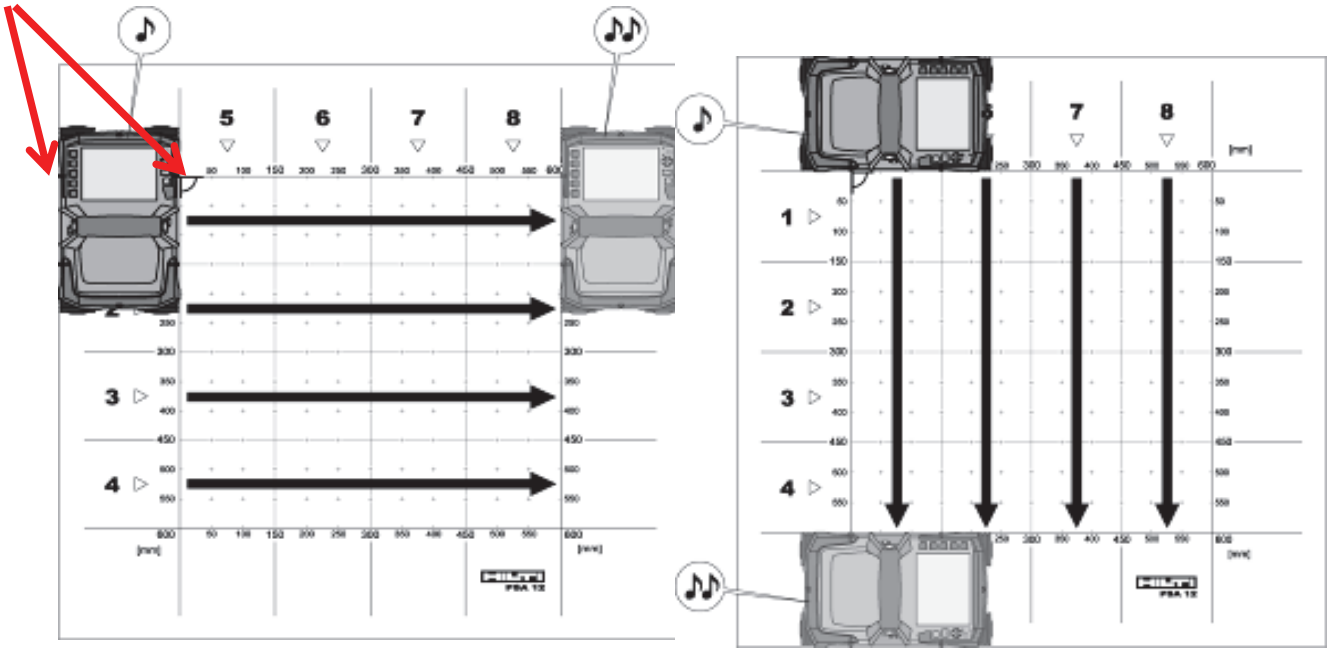


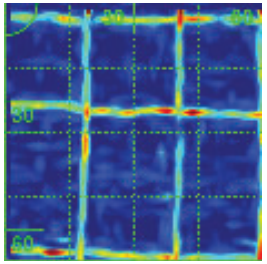
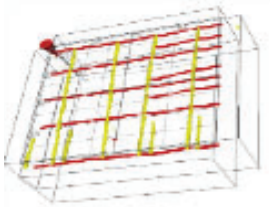
Top view
Cross view
Depth indication
Distance indication

Imagescan

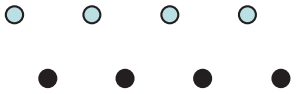
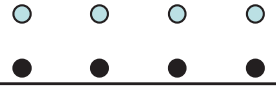
Place the scanner according to the black grid line

- Two dimensional scan
- Two size grids (600x600mm & 1200x1200mm)
- Depth range: 30 cm
- Results obtained right away



1. Attach reference grid	2. Scan	3. Analyze results	4. Mark results
		 2 D view  3D view	

General recommendations for IS and QS

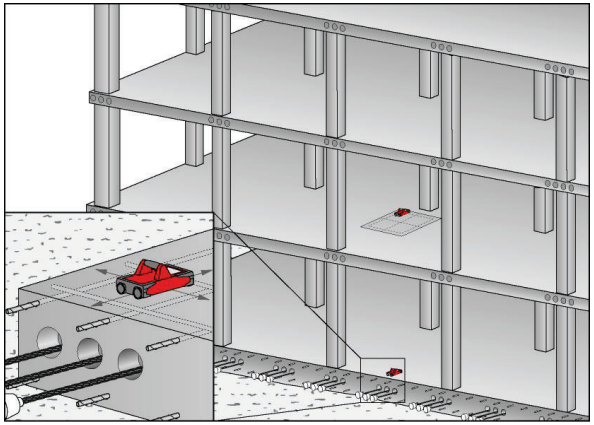
Imagescan Quickscan		10 mm - 50 mm	50 mm – 200 mm	200 mm – 300 mm	remarks
Single rebar		☑	☑	☑	
Air hole		☑	😐	☹	Depending on diameter (>25mm)
Mesh = 50-100mm		😐	☑	😐	
mesh ≥ 100mm		☑	☑	☑	
Profile/ Q-Deck		☑	☑	☑	Probably only the edges are shown.
Metal plate		☑	☑	☑	Middle part may be displayed weaker.
2nd layer (spacing>130mm)		☑	☑	😐	Spacing>130mm
2nd layer		☹	☑	😐	Both layers embedded within 10-50 mm don‘t assure enough vertical separation (min 40mm)
Floor heating		☑	☑		Not with metal heat spreader below
Tendons (s>130mm)		☑	☑	☑	Not too steep falling

Applications overview

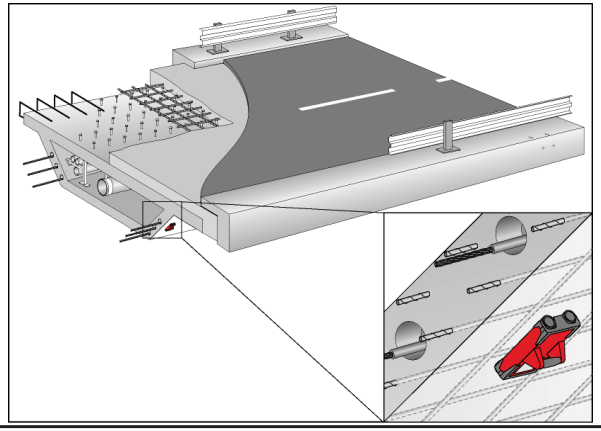
Application	Trades	Examples
Safe drilling	**All trades**	Drilling and coring applications
	BC	Diamond coring and through drilling applications
	CE	Diamond coring, sawing and through drilling applications
	SM	Fixing steel fabrications and steel beam erections to base plate (renovations, rebuilding and new build)
	DSC	Prevent hits for coring, drilling or sawing applications
	Mechanical	Pipe run installations
	Electrical	Cable and cable support installation
Embedding of objects	**BC**	Post-installed rebar extensions, under ceiling rebar fixings
	CE	Bridge construction, adding's of support beams, rebar and post-tension cable extensions
Object location	**Mechanical**	Renovation purposes
	Electrical	Renovation purposes
	Utilities	Renovation and maintenance purposes
Quality control Supervision	**BC**	Quality of concrete, voids, pre-stressed enforcements
	CE	Quality of concrete, voids, cracks, pre-stressed enforcements; Bridge maintenance, control, WWT, NPP, Energy
	Government	Quality of concrete, voids, cracks, pre-stressed enforcements; Bridge and highway maintenance

In many Hilti core trades safe drilling is a key application

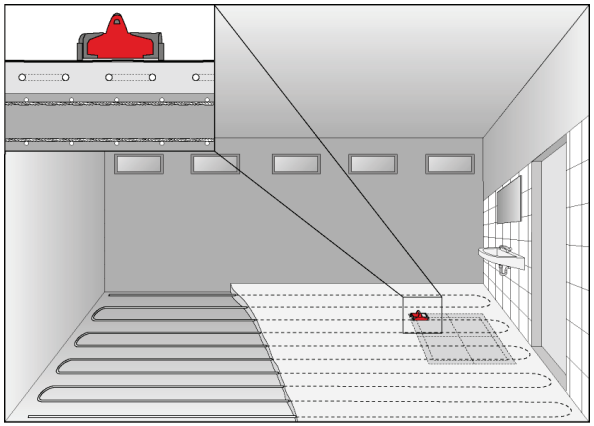
BC



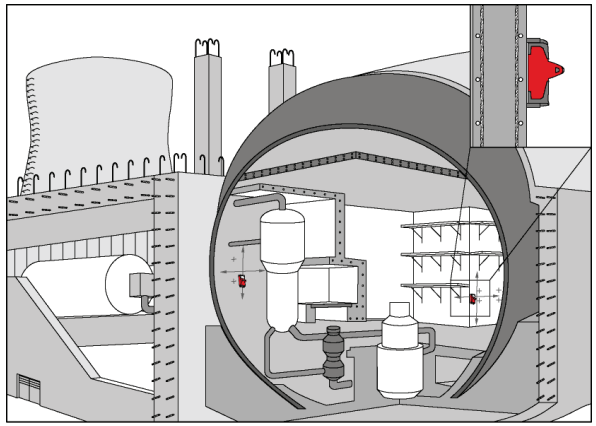
CE



M / Maintenance



Energy



A clear value proposition

- Peace of mind: safe drilling and coring, avoid collateral damages
- Safety
- Structural analysis

- Avoiding one tendon hit pays off the tool!

PS 1000 X-Scan
Product Training

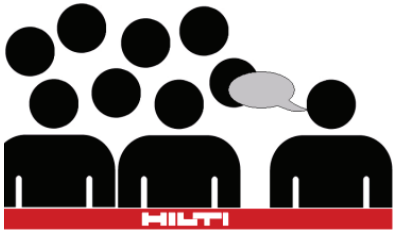
Sales approach: Killer sales arguments

	Customer need	Customer Value / Sales Argument	Product feature
Outperform	High productivity, accuracy and reliable measurements	• Immediate true image of objects embedded in concrete structures: no data transfer or long processing time • High detection performance • High scanning efficiency	• Build in display and data processing capabilities • Various scan modes for different applications: – Quickscan for direct marking out of found objects – Imagescan for picture generation (easy location of objects) • Antenna array (allows fast scanning and high data quality)
	High working comfort and safety	• Working comfort on ladders / scaffolding; freedom of movement; safety; high ergonomics	• Cable-less tool operation • Comfortable to use over long periods of time • Non-destructive testing equipment
Outlast	Ease of use and jobsite fit	• Straightforward to use • Suitability for work in a construction environment	• Immediate image, scanning large areas and menu-driven displays make scanning easy and result interpretation easier • Quick and easy set up time • Robust construction, shock resistant, dust and water protection
	Service	• Saving value for the customer • No cost respectively calculable costs • No upfront investment, full service, theft protection	• 2 year no costs • Lifetime manufacturer's warranty & repair cost limit • Fleet management • Calibration Service

Go to market: competence build up with sales teams remains essential

	Key success factors for PS 1000 X-Scan sales		Building Construction Example
Competence	• Understand the basic application	→	• Finding safe spots for drilling and coring
	• Understand who are target customers	→	• General contractors with/without detection expertise
	• Know how to professionally demonstrate the tool in its application	→	• Set up the tool, do Quickscan (and Imagescan), analyze data, mark safe drilling spots
Sales	• Steering – understand the potential	→	• PS 1000 in BC: 1-2 tools per team/month
	• Van inventory – have complete system	→	• Tool, monitor, PC software, cables
	• Demonstration – know when to go on job site	→	• Site preparation, concrete walls/floors, dryness of concrete, place to attach the grid
	• Value proposition of PS 1000 in Fleet	→	• Innovative; calibration free of charge

Introduction/ Kick-off



Basic script:

1. What is the customer need?

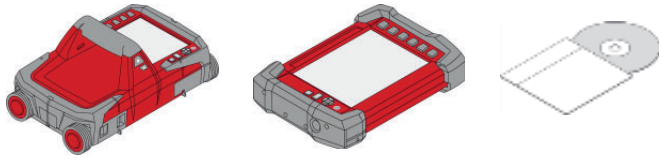
Tool can find all kinds of objects,
at all depth,
with object classification,
in multiple layers,
and is easy to use and interpret.

To save money (repair) and time (downtime).

No expert skills needed to use it.

2. What solution do we provide?

Tool can find all kinds of objects,
up to 30 cm depth range,
in multiple layers,
And is easy to use and interpret.



Key take away: PS 1000, a tool that fulfills most customers' needs, which outperforms current solutions and which allows huge potential with a wide range of Hilti customers

MEETING DEMO

3. What do TS need to know?

- Basic technical data
- Systems offerings/target group
- How to use the tool
- Main benefits
- Typical application for his trade

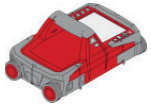
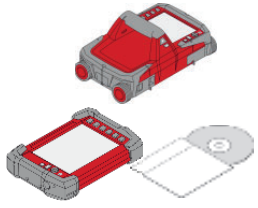
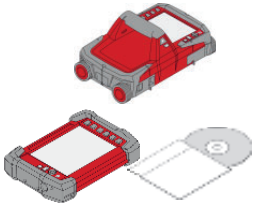
4. What do FE need to know?

- Specific technical data
- Systems offerings/target group
- How to use the tool, the monitor and the PC Software
- Main benefits for each tool in each customer segment
- Typical applications per trade

5. Sales approach/demo

- Pricing
- Demo tool policy
- Sales target
- Systems fit

Demonstration concept per customer segment (1/2)

	DETECTION NON-USERS		DETECTION USERS
BC / CE	50%	50%	50%
DSC	80%	20%	
ENERGY	50%	50%	50%
I & G	50%	50%	50%
NTD / I			100%
	PS 1000-B	PS 1000	PS 1000
			
	Demo 1	Demo 2	Demo 3

Demonstration concept per customer segment (2/2)

	NON-USERS		USERS
Customer application	Finding a safe spot for drilling	Finding a safe spot for drilling and some further analysis	Mapping out objects, jobsite data analysis and further office documentation
Used functionality	QS and IS (small grid)	IS and monitor (view data)	IS (big grid), monitor (view data in jobsite) and PC Software (office analysis)
Main benefit	Show how easy to set up, use and interpret the tool is		Show productivity gain and ease of set up, use and interpretation. Show monitor and PC SW functionalities
	PS 1000-B	**PS 1000**	**PS 1000**
	Demo 1	**Demo 2**	**Demo 3**

For all segments: key selling argument: LTS and FM.

QS - Quickscan

IS - Imagescan

Demo concept

On jobsite

A. Locating object

1. Localize objects on a wall the customer is currently working on. Mark where objects are located. Show Quickscan detection.
2. Find a more tricky location (PT deck, conduit embedded, more layers rebar. Show Imagescan (big size if possible). Show how to slice/dice concrete
3. PS 1000 System: show monitor analysis capabilities including 3-D visualization

B. Show return on investment

1. Money saved avoiding one PT cable or electrical conduit objects embedded.
2. No risk, no safety precautions, no dependency of external company

How to demonstrate:

A. Localization performance
Find out if customers ever made a negative experience hitting objects and if he would be interested to avoid them again.

Perfect demo movie

B. Show value for money
Find out how much it costs when customers hit water pipes to repair damage.

Find out how often the customer calls an expert for layout marking. Do the calculation!

In office

A. Locating objects

1. If possible show live demo on concrete floor / wall. Show how easy it is to identify object location.
2. If no real demo is possible show available scan on scanner / monitor – explain the ease of use and interpretation, incl. 3-D
3. If no tool is available, show PC SW and visualization capabilities of objects in concrete

B. Show return on investment

1. Money saved avoiding one PT cable or electrical conduit objects embedded.
2. No risk, no safety precautions, no dependency of external company

Demo concept EM sensor

On job site

A. Locating object

1. Localize objects on a wall where an electrical outlet is present. Mark where objects are located. Connect a Hilti Power tool / PSA 81 charger. Show Quickscan detection without / then with EM detection result. Mark location.
2. Find a location with conduit(s) embedded. Show Imagescan (big size if possible) result without EM / then switch to EM sensor data – indicate location.
3. Alternative: if no actual location with conduit can be found use demo scan provided.

B. Show return on investment

1. Money saved avoiding hassles and risk of hitting electrical conduit objects embedded.

How to demonstrate:

A. Localization performance

Find out if customers ever made a negative experience hitting electrical live wire conduits and if he would be interested to avoid them again.

Perfect demo movie

B. Show value for money

Find out how much it costs when customers hit electical power lines / conduits to repair damage.

Find out how often the customer calls an expert for layout marking. Do the calculation!

In office

A. Locating objects

1. If possible show live demo on concrete floor / wall. Show how easy it is to identify object location.
2. If no real demo is possible show available demo scan on scanner, switch back and force of radar and EM sensor data – explain the ease of use and interpretation
3. If no tool is available, show video / images on phone of conduit detection in concrete

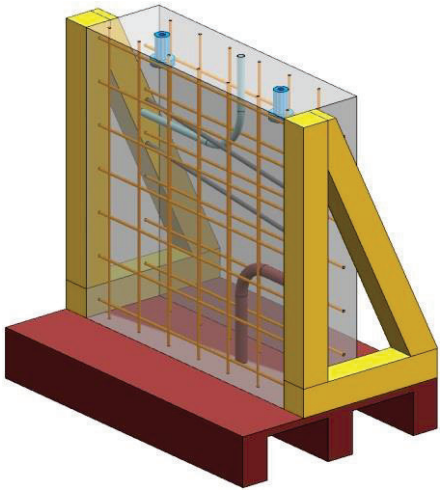
B. Show return on investment

1. Money saved avoiding hassles and risk of hitting electrical conduit objects embedded.
2. No risk, no safety precautions, no dependency of external company

Demo concept for kick-off

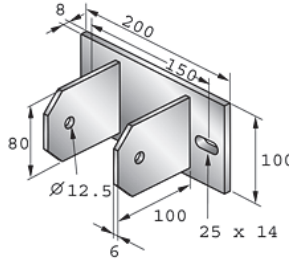
Kick-off

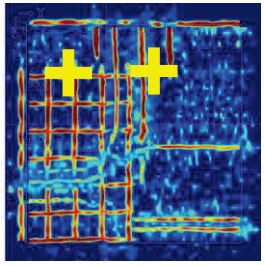
- Use PS 1000 demo block and insert live wire with light bulb or power cord with VC 20 connected (running)
- Have anchor plate with 4 holes available
- Conduct Imagescan
- Find 2 safe spots for fixing steel plate connection (MIC-CU)
- Position anchor holes in RADAR image
- Ask for allowance to drill
- Then switch to EM Sensor data – show cursor position – clearance for drilling?
- Discuss customer benefits, target group, EM sensor specification and requirements (current, load), pricing concept

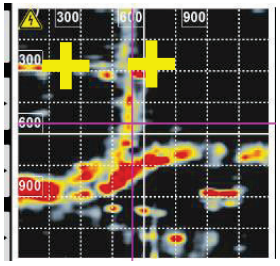


Demo block sample, different ones available in MOs

Material required:







Demo support materials provided for EM sensor

- Demo scans (for sales personnel with demo tools)
  - Electrical conduits, junction boxes, … with current
  - Electrical conduits with no current
- Demo scan images in photo gallery for smartphones (RADAR / EM)
  - Suited for AM/TS to upload to their smartphones (for sales personnel without demo tool available)
- Demo video – story line similar as kick-off – language neutral
- Tips and Tricks manual – enhancement to existing RADAR brochure for sales personnel and customers
- FAQ's – guidance for sales personnel and customers
- Quickguide manual – how to get started, operation, what to expect, limitations

DEMO CONCEPT: DETECTION NON-USERS

Demo 1 & 2

Starting questions	Aim: Create interest

- Which kind of applications do you usually do? Understand customer needs and identify application range.
- Are you using detection tools today? What is your experience concerning usage of detection tools? Identify customer expertise.
- How often do you use detection tools or you hire a detection company? See the intensity of detection works.
- How long does it take to arrange a visit and wait for a detection company and for a detection company to do scanning? How much does the service cost? Understand the timing problem of hiring a detection company and costs of detection services.
- Have you ever considered using detection tools by yourself? Understand customer fears and misconceptions.
- Do you need scanning documentation as well? Find the right tool to demo.

DEMO CONCEPT: DETECTION NON-USERS

Demo 1 & 2

Visit at the office **Aim: Get a real demo on the jobsite**

- Ask the right probing questions.
- Explain the two product concepts and highlight their features and benefits.
- Demo the tool on a concrete wall or floor. If not possible, upload saved data on the demo tool or monitor and show the obtained results.
- Respond to input questions and highlight relevant product characteristics:
  - Simple tool operation
  - Easy to interpret results
  - Fast, immediate visualization and reliable

  } **No expert skills needed!**

  - Service: Lifetime Service (LTS) and Fleet Management (FM)
- Remind the main benefits:
  - Time saving: No waiting time for expert, no repair time.
  - Cost saving: High costs of hiring a detection company several times. Hitting one tendon cable pays off the tool. Repair costs.
- Try to get a second customer visit in which you can perform the applications on the jobsite.

DEMO CONCEPT: DETECTION NON-USERS

Demo 1	Demo 2
Visit at the jobsite	**Aim:close sale**

PS 1000-B

- Show the tool functions and explain briefly the tool operation.
- Start with Quickscan detection and locate and mark objects on a wall/floor.
- Make the customer use the tool and interpret the results by himself.
- Continue with Imagescan (small grid).
- Show him the main menu features and finally mark on the wall the founded objects.
- Address time and cost saving
- Ask him how difficult was it to perform the applications.

PS 1000

- Show the tool functions and explain briefly the tool operation.
- Start with Quickscan detection and locate and mark objects on a wall/floor.
- Make the customer use the tool and interpret the results by himself.
- Continue with Imagescan (big grid).
- Transfer the results to the monitor and show him the benefits of it as well as its features.
- Address time and cost saving.
- Ask him how difficult was it to perform the applications.

See demo guide

DEMO CONCEPT: DETECTION USERS

Demo 3

Starting questions	Aim: Create interest

- What kind of applications do you usually do? Understand the customer needs for hit prevention and structural analysis.
- Which instrument do you use for each of the applications? Get to know the product portfolio and way of performing certain applications.
- What is important with these tools? Learn customer preferences.
- What kind of problems do you usually face? See the limitations of the competitor tools/instruments used.
- What kind of services does your company offer? Get information on scope and gaps of satisfaction.
- How many scans can you perform in one day? How long does it take to do one scan? Understand timing problems of a customer.

DEMO CONCEPT: DETECTION USERS

Demo 3

Visit at the office **Aim: Get a real demo on the jobsite**

- Explain the tool concepts and highlight their features and benefits.
- Demo the tool on a concrete wall or floor. If not possible, upload saved data (scanner or monitor) and show the obtained results and show the customer the obtained results. Use also the PC software.
- Respond to input questions and highlight relevant product characteristics:
    - Simple tool operation and set up.
    - Easy to interpret results (with immediate visualization).
    - Fast and reliable.
    - PC compatibility with PS 250 results
    - Service: Lifetime Service (LTS) and Fleet Management (FM).
- Remind the customer's main benefits:
    - Efficiency: Tool works faster, it is up to 80% more efficient than existing systems.
    - Increase of profit: Less time per detection job means more time for other detection projects.
    - Safety over X-Ray
- Try to get a second customer visit in which you can perform the applications in the jobsite.

DEMO CONCEPT: DETECTION USERS

Demo 3

Visit at the jobsite	Aim: Close sale

- Show the tool functions and briefly explain its operation.
- Present Quickscan for fast and easy detection and direct marking; let the customer continue and interpret the results by himself.
- Show the Imagescan and let the customer scan and analyze the obtained results.
- Bring along the monitor and show its performance (2-D and 3-D visualization) as well as its menu features and main benefits.
- Try to bring along their competitor tools and perform the same application.
- If requested, talk about the different accessories and their benefits.
- Compare the time spend and the results obtained. Talk about the productivity gain of about 80% with existing solutions.
- If the company uses X-Ray talk about the safety precautions.
- Talk about documentation and the PC Software. Offer to the customer the chance to see the results in a PC.

See demo guide

DEMO CONCEPT: SUMMARY

	PS 1000-B NON-USERS	PS 1000 NON-USERS	PS 1000 USERS
MAIN BENEFIT	Ease of use, set up and result interpretation (tool)	Ease of use, set up and result interpretation (tool and monitor)	Ease of use, set up and result interpretation (tool, monitor and PC SW). Productivity gain
OFFICE	Demo: QS and IS Let the customer use it and interpret the obtained results Discuss benefits	Demo: QS and IS Show results in the tool and in the monitor Discuss benefits	Show results in the tool, monitor and show detection center online. Talk about software
JOBSITE	Demo: QS and IS Let the customer use it and interpret the obtained results Discuss benefits	Perform Imagescan using the big reference grid and show the results Discuss benefits	Focus on the results on the monitor and show features. Talk about productivity and visualization

Always remember: Service is a key selling argument (LTS and FM).

Checklist for a perfect PS 1000 X-Scan demo

1. **Be prepared**
   - Know your customer, have PS 1000 X-Scan full system with all relevant accessories and charged batteries
   - Use the demo guide as quick reference to refresh knowledge, use the tool before and learn the system components to use
   - Prepare project folder on scanner and monitor (customized for customer to be visited)

2. **Try to demonstrate in real working environment (relevant tasks)**
   - e.g. checking rebar layout with Imagescan and Quickscan Detection
   - Don’t show every functionality in the tool – keep it simle

3. **Show how to use the Scanner, Monitor & how to transfer data**
   - Show how easy and user-friendly PS 1000 X-Scan is, and how quick results can be seen on site

4. **Show key functions of PS 1000 X-Scan, PC software for assessment reporting capability**
   - Demonstrate how monitor enable customer to analyze data on site and easily produce professional reports back in the office
5. **Talk about great benefits of Hilti Services (Life time service, Fleet management, Calibration service)**

6. **Have sales literature with you** – Product leaflet and application guide

Things to remember!

Demonstration basics:

- Don't OVERSELL!!! Know the applications and detection range and limitations of the system.
- Check the settings before your visit – tool shut off doesn't reset to default settings
- PS 1000 X-Scan is easy to demonstrate when focus is put on important customer needs

Tips & Tricks:

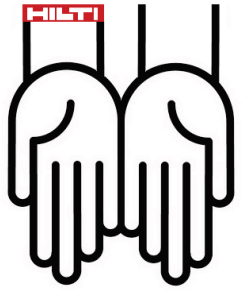
- Make sure that the scanner wheels are clean, free from dirt and not worn.
- Use an overlay in case the scanning surface is rough
- All 4 scanner wheels have to run on the surface. Use overlay in case the scanning area is not wide enough
- Don't scan too fast – the scanning performance might be reduced
- Check the battery status of monitor and scanner before the visit. Don't remove battery while tools are switched ON. Data might get lost.
- Make sure that enough memory space is available on scanner and monitor. Do not remove memory card while scanner is switched ON. Data will get lost.

Key buying criteria:

- **Reliability**
- **Ease of use**
- **Visualization**
- **Advanced data analysis**

The following support material will be provided

Highlight tool usage and benefits	
Demo tools	BU sponsored tools will be dedicated to the markets.
Demo / Sample scans	A set of demo scans will be provided for customer visits and for competences bulid up
Sales literature for support	Argue cards, video, leaflets, Tips & Tricks, FAQ are provided (see Compass)
Demo guide	Various demo guides are available (see Compass)



This is not a ordinary launch – key success factors for a good market preparation

	Launch preparation	Launch	After Launch
MO	• **Commitment for resources** marketing, sales/techn. support • **Build up awareness** • Assessment of HRP • Set potential based INPs	• **Sufficient FE field support** • Allow enough time for **training** • Investment in **demo tools** (1 tool/region) • Investment in **loaner tool pool**	• **Sufficient FE field support** • Commitment for continuous **competence build up** • Keep **awareness** (e.g. association work, trade show) and cross BU/trade initiatives
Trade	• Commitment for full **utilization on application chain**, cross selling opportunities		

Expert Phase 1 (4 campaigns)

1	**FS ferroscan customers for trade in:** All size classes	Direct mail	Follow up TS lead 1
			Direct TS lead 2
2	**Existing BC customers:** experts / planers / specifiers (buying, specifying anchors)	Direct mail	Follow up TS lead 1
			Direct TS lead 2

Perfect demo:

Demo the function customer needs most (Quickscan for checking concrete coverage, Image & blockscan for rebar layout/analysis)

Perfect argumentation, Van stock:

PS 250 leaflet

PS 250

Evaluation and review:

Review how many customers opened e-mail

How many demos performed at customer

How many tools sold

Expert Phase 1 (4 campaigns)

3	**Existing CE customers:** All size classes (Buying anchors, drilling and dia. Tools)	Direct mail → Follow up TS lead	1
		Direct TS lead	2
4	**Existing energy customers:** All size classes (buying anchors)	Direct mail → Follow up TS lead	1
		Direct TS lead	2

Perfect demo:

Demo the function customer needs most (Quickscan for checking concrete coverage, Image & blockscan for rebar layout/analysis)

Perfect argumentation, Van stock:

PS 250 leaflet

PS 250 demo tool

Evaluation and review:

Review how many customers opened e-mail

How many demos performed at customer

How many tools sold

Expert Phase 2 (3 campaigns) (launch/post launch PS 1000)

1	Existing BC customers: Size class B,C,D (Buying anchors, rotary hammers, combis, drill bits, dia. Tools)	Direct mail	Follow up TS lead 1
			Direct TS lead 2
2	Existing CE and energy customers: All size class C,D (Buying anchors and dia. tool)	Direct mail	Follow up TS lead 1
			Direct TS lead 2
3	Existing PS 200/ PS 250 customers:	Direct mail	Follow up TS lead 1
			Direct TS lead 2

Perfect demo:

1) Scan over structure and mark out objects detected.
2) Perform an Imagescan and see the immediate results on the scanner
3) Transfer data to monitor to show 3D view of inside structure

Perfect argumentation, Van stock:

PS 1000 leaflet

PS 1000 demo tool

Evaluation and review:

Review how many customers opened e-mail

How many demos performed at customer

How many tools sold

A structured, multi leveled MCS approach to introduce PS 1000