

Ground Penetrating Radar Systems & Their Use



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- when it has to be **right**

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This second part of our white paper series on Ground Penetrating Radar (GPR) focuses on a range of equipment which includes electromagnetic cable locators, handheld high-frequency GPR, utility detection GPR, multi-array GPR systems, GPS and TPS, collection software and post-processing software, in fact, the whole range of products when looking for a complete solution from detecting / locating to reporting.

You've stopped dipping your toes in the water and taken the plunge, you've done your homework, had the demos, done a bit of quote ping-pong, and finally made a decision. You work for a great company who has the possibility to have a C-thru system, Leica DSX, Leica DS2000, IDS Stream-C array, positioning system and post-processing software, whoo hoo! Notice I forgot to put training in there? Well, that's because that's what happens, training is forgotten about in the bigger scheme of things! Did you know that Leica Geosystems will tailor a training course especially to suit your needs, and the trainer (hello) will come to you if you want and do the theory, practical use, tips and tricks, processing, export of data, and even sort the CAD out. We can do that live on a job if it's easier, just get the trainer for a day or ask for an assisted survey.

First things first though, are all you operators out there aware that all GPR systems including hand-held units may and will come under licencing control depending on what your locale is? Let's check the European and US regulations. For example, in the UK we need to have an Ofcom licence to operate and abide by its rules.



Requirements and Guidance Notes for
Ground Probing and Wall Probing Radar

OFW 350

European regulations: <http://www.eurogpr.org/vn2/index.php/rules-regulations/licensing-rules> and implementation map: <https://www.efis.dk/views2/map.jsp?maptype=0&annex=9&row=76>

UK regulations: <https://www.ofcom.org.uk/manage-your-licence/radiocommunication-licences/licensed-short-range>

US regulations: <https://www.fcc.gov/engineering-technology/laboratory-division/general/equipment-authorization>

A C-thru what?

For those that don't know, the IDS C-thru is a handheld GPR system that can be used for Non-Destructive Testing, concrete inspections, structural analysis, bridge deck analysis, in fact anything, when you want to perform high-resolution shallow investigations. Unfortunately, we haven't got all the time in the world to chat about everything, so we will try to stick to basics. It's a 2Ghz system so is defined as high-frequency, but uniquely has two antennas with different polarisations. Yes that's right, it has one antenna with H-H configuration and one antenna with V-V configuration. If you remember what we said about that last time in the previous white paper, then this little gem can 'see' things in the medium being investigated that are in both directions with relation to the scan line. This gives the unit the ability to 'see through'...C-thru, to the next layer of rebar below if you're using it for that purpose. The thing about high-frequency, though, is if you want high-resolution data, the higher frequency means you will have a short operating time window.

! Higher the frequency, the shorter the wavelength, the smaller the antenna, the shorter the operating time window is.

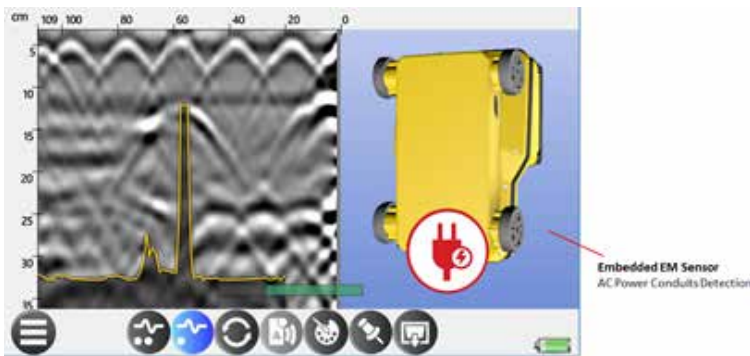
The system uses positioning lasers and a reflective bar system to keep the scan lines parallel when recording data, this is useful when reviewing data and re-positioning yourself in the recorded grid to mark drill locations for example. You don't have to use the reflective strips, you can go old-school and use paper print grids, free-style by marking grids on the floor, or you can scan in single line mode. You can review data live on the screen. There's a cool remote desktop mode

where you use a remote tablet to view the scanning screen. The telescopic handle accessory is perfect for those hard to reach places.



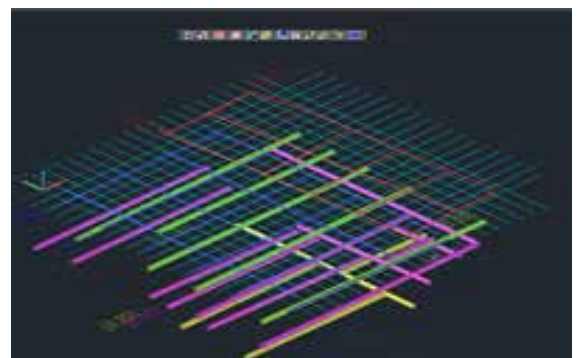
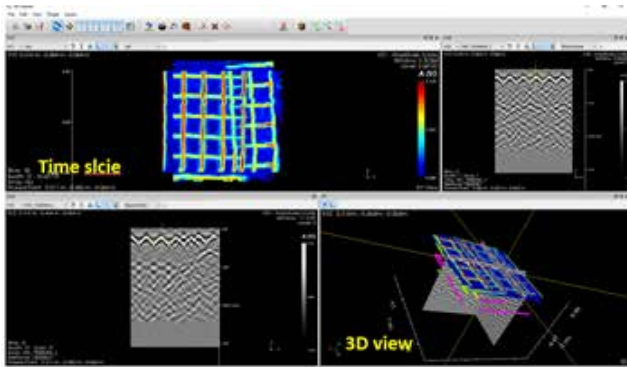
A few of the features we have just mentioned are shown here in this image.

The IDS C-thru also has an embedded electromagnetic sensor. With this feature enabled, the operator is able to detect live power cables where current is flowing, that may be present in the medium under investigation. You simply select the operating frequency for your locale - 50 or 60 Hz, when current is detected you get an on screen visualisation llive in the viewing window, see below;



As you can see the data collected is clear and very usable for live analysis. The IDS C-thru operating system allows you to customise the operating screen view, rotate the viewing screen, depending on which way you are scanning, and uses the family of control button icons that run through the entire range of GPR available through Hexagon. Hyperbola fit, depth collection options, 4-wheel encoding are all featured to that make this a really nice system to use.

The data can be downloaded simply via USB for viewing, and, if necessary, processed in IDS GRED HD, the post-processing software.

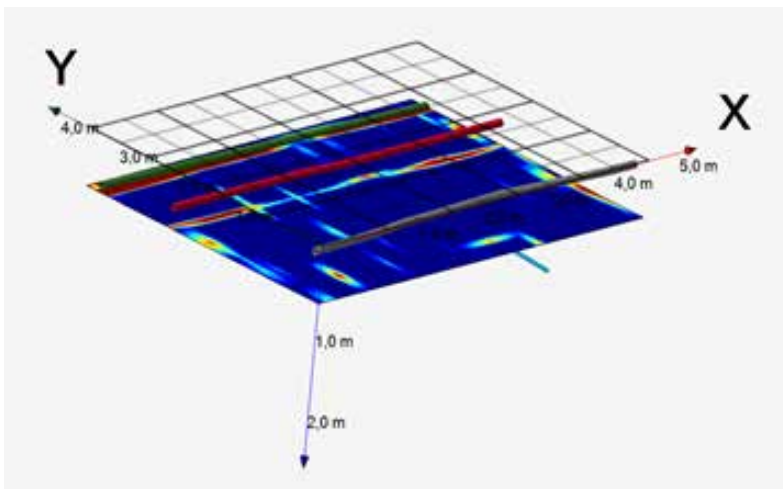


We will cover software and processing another time.

Leica DSX



The Leica DSX does things a little differently, but in a really good way. If you're an experienced user, then you might not like the idea of that. All you GPR "nerdies", me included, embrace the technology, it hasn't been designed and built to make us guys obsolete. It's been designed to make GPR more accessible to users who don't need or maybe don't possess (yet) the expert skills that we might have. It uses GPR technology in a traditional way, it comes as a push along cart system; looks like a GPR should look like, it's got a tablet on it, you can use a GPS or TPS to position with. So, what does it do differently? Well, it has a unique software design called DXplore that enables the user to pick targets and assign attributes to them and show them live inside a 3D cube on screen. That's progress guys and girls.



Data from the DSX, collected and analysed in roughly 15 minutes in total.

The Leica DSX uses a 600Mhz frequency antenna, and the software tailors the incoming data to give a 2 metre operating window, based on ground conditions. Remember we can't change the laws of physics, we have to work with them, it's a GPR so follows the normal rules. The software ensures that the system is functioning correctly at the start of every scan line or swath and that data is 'in the correct place' for the algorithm to function correctly. The system works in grid mode, how else do we produce 3D cubes if we don't collect in a grid mode method? The antenna has H-H polarisation so we have to 'see' our targets at 90 degrees to our scan direction, and combined with 50 centimetre scan separation, the algorithms do the rest. GPS connectivity is just how we normally do it. Pop a sim card in the tablet and forget about having to have cell phone hotspot for corrections. The 'GG04 plus antenna' gives great results via Zeno Connect, and the flagship GS18T antenna gives tilt compensated measurements for all those wobbly moments.



The Leica DSX - looks like a GPR and does what a GPR should. The software, though, is a bit different.

We are greeted by a home screen split into four sections. The left side panel has some helpful videos to get you going, the centre panel is where you load or start a new project, the central lower panel is a live status monitor and the icons change to green when active, the right side panel shows recent projects for easy access. Settings in the top left corner sets language and metric / imperial settings.



Intuitive screen selection options quickly get you going. First we get to file naming and save location for the data. It is recommended to change the default file save locations



The next screen sets the grid parameters; the origin button sets the coordinate system if being used; the layers button lets us use background mapping or load a DXF for reference. Then simply position yourself on screen with the tool.

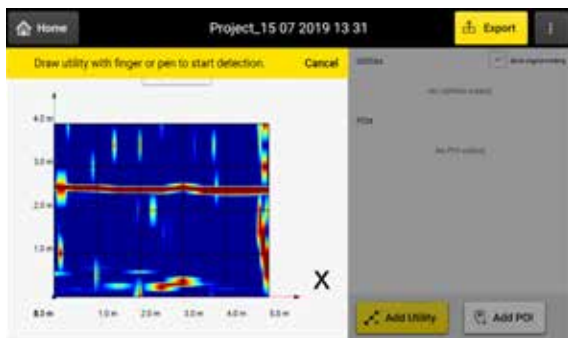


The next screen gives a summary of your previous selections. You can edit, save draft for use later or go to acquisition.

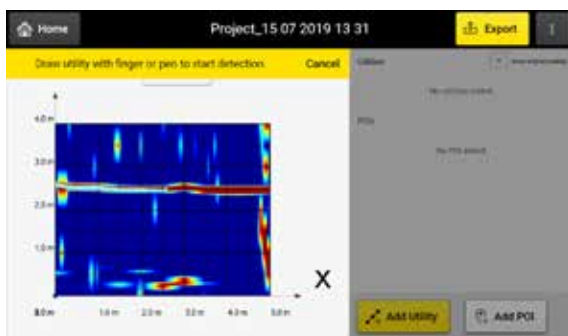


The acquisition screen shows the user the grid line positional reference on the left, progress is monitored on the actual grid with the live GPR position, and a green line indicates a completed scan line. Obstructions can be navigated around using the arrows. Each scan must be started and stopped individually, but you can snake up and down the grid. The add POI button allows you to add a surface feature live in the scan. For example, if you have located a cable (yes we would always use a cable locator before GPR), simply add the EML button at the point along its route. If used with a GPS or TPS, the path of DSX is visualised on screen in near real-time, allowing for accurate alignment and corrections of the acquisition path based on visual representation.

The Leica DSX comes with four red positional guides along the chassis use these to help align yourself in the grid and position the centre of the antenna above a point if using the POI function. When the scanning process is complete, press the analyse data button



This final analysis screen is where you select targets, simply by using the add utility button and drawing on the tablet screen along the high contrast line where you think a utility should be found, like the image below.



The software does the analysis and will give either a utility or a anomaly decision.



This is then editable, color, size, type, etc. The time slice function enables you to search through the data to perform the selections. Navigate around the 3d cube using the controls. The export section is just that, use the onboard report format, export tomography as an image file, export to DXF, the choice is yours.

A brief snapshot of the new kid on the block, we're not doing a training here, there is more, you don't get all the tips and good stuff. Let's move on.

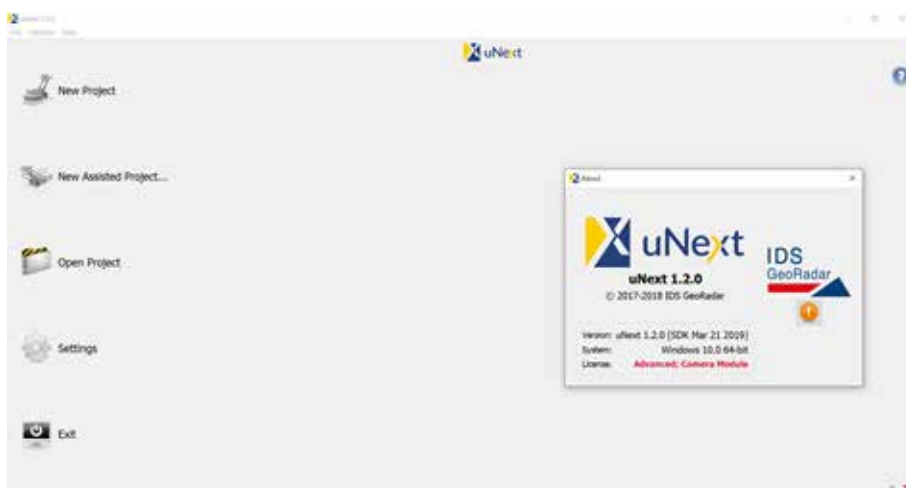


Leica DS2000

The Leica DS2000 is a dual-frequency system and operates with two frequencies, 700Mhz and 250Mhz. It's been around for a while and for all us old timers, it's familiar, like a cozy old arm chair. It's reliable, predictable and does exactly what it says on the tin. Like the Leica DSX it has a folding handle to keep it compact for transporting around, uses the same style tablet, does the same thing GPR wise. But, and there's always a but, you need to know what you are doing with this one. That sounds ominous, and I'm not trying to scare you off here. The Leica DS2000 does things the traditional way and displays data back to you the traditional way...in a B-scan view, so it's better to know how to get the best out of it and understand what the display is telling you.

The current version of the data collection software is IDS Unext version 1.2. It is a nice piece of software, it allows some control over how to collect the data and how you visualise the data whilst live in the scan. There's a target picking feature, hyperbola fitting, reporting and export function including a 3D DXF style, Geomap export. Again this system can do positioning by GPS and TPS and is simple to set up.

The system starts into the following screen;



Simple menu settings lend themselves for a straight forward day at the office. The left hand side menus offer;

New Project*



this feature is where you perform all projects that use GPS / TPS. This can include geo-referenced grids, also for data collection along single scans and 'straight-line' projects.

Background mapping can be used in this feature, either satellite imagery or imported measured drawings with live positioning.

Open Project



this feature allows you to access the existing or custom file directory to access previous survey projects stored in the computer or from an external storage device or source.

Exit



this feature exits the uNext application in this screen.

New Assisted Project*



this feature is where you perform grid-based projects and is non-GPS / TPS for data collection. You input your parameters in the set up for the grid size and spacings for you project.

Background mapping can be used in this feature, either satellite imagery or imported measured drawings with live positioning by using the reference line function for swath positioning.

Settings



this feature allows you to access the set-up menus for the operating system where you can personalise and tailor the settings for the project



Displays the version and licencing function, I have the advanced licence installed as shown.

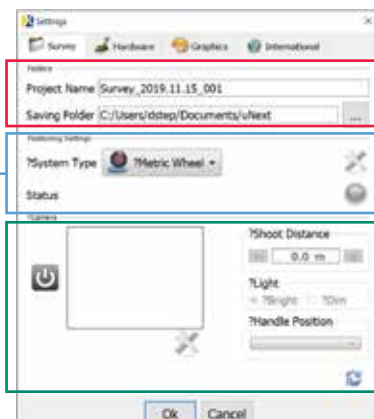
*Available when system connected and ready to go.



By accessing the settings feature, you will be taken to the following screen:

This survey tab accesses;

The System Type button is where you access a drop-down menu to specify your collection. mode.



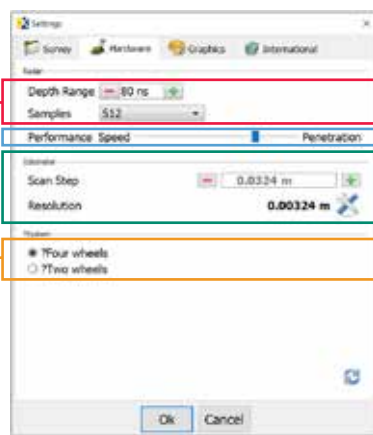
Here you can change the default save file destination. Custom project file names can be used for easier file recollection.

Here you can change the default save file destination. Custom project file names can be used for easier file recollection.

The hardware tab accesses;

Here you control the depth range setting for your operating window and the vertical sampling resolution parameters for your project if needed.

The System Type button is where you access a drop-down menu to specify your collection. mode.



The Performance Speed slider can be adjusted for individual sites. The position as indicated gives good overall performance.

The odometer section is where the survey wheel encoder values are set based on the project

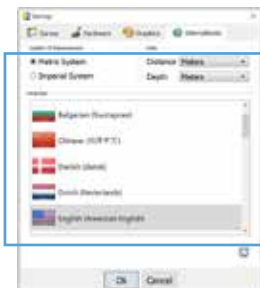
The graphics tab accesses;

The drop-down menu allows you to select a different colour palette to view the data, a useful tool as each palette setting displays the signal amplitude colours differently to the user.

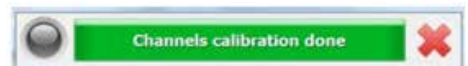


The international tab accesses;

The user selectable region language can be set along with the measurement system, either metric or imperial.



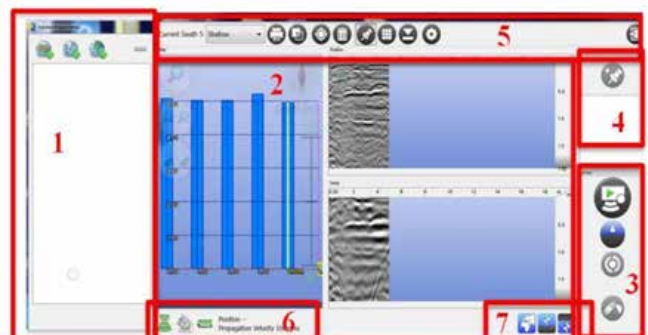
That covers the opening screen and its functions, let's go to New Project. On selection, the system performs a check to ensure normal operation, the following window will appear



You're now good to go as the system Channel calibration check is OK. You can get a system error message here if you have a problem. We are good to go though.

The New Project collection (acquisition) screen, consists of several tool bars both vertically and horizontally arranged. These can be moved, resized, be visible or not depending on your personal preference. The familiar family of buttons are used that we found in the C-thru, there's just a few more.

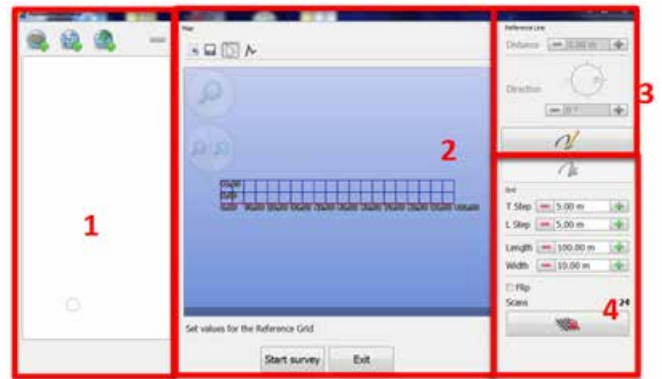
- **Section 1** - working with background satellite imagery or image file is controlled here.
- **Section 2** - this is the work area 'world map' and displays the individual swaths relevant to the collection period. Image file or satellite background imagery would be displayed if being used and the scans positioned accordingly when used in conjunction with a positioning system.
- **Section 3** - swath acquisition command tools - start / stop, backwards / forwards, map graphic settings and auto spray (if supported) are all controlled here.
- **Section 4** - Target picking and command features.
- **Section 5** - General acquisition tool menu.
- **Section 6** - System status information.
- **Section 7** - On Screen window visualisation selection - select between world view, shallow or deep antenna, all, some, the choice is yours.



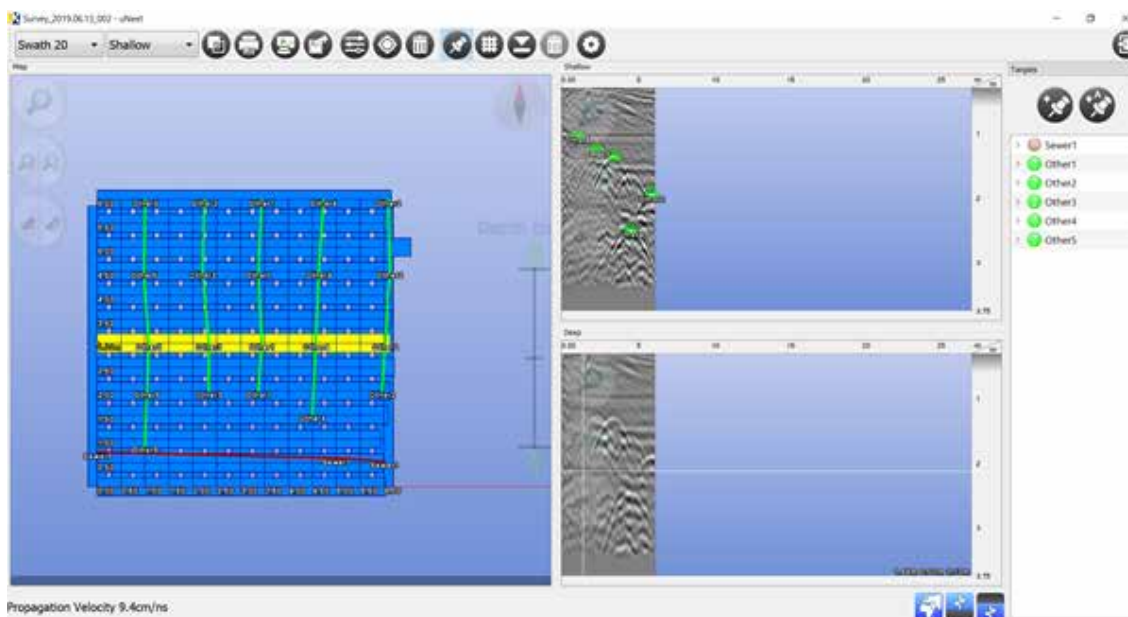
If you want to collect in grid mode then The New Assisted Project is for you; this though is collected with no external positioning.

The New Assisted Project screen looks a bit different and has four sections;

- **Section 1** - working with background satellite imagery or image file is controlled here.
- **Section 2** - this is the work area 'world map' and displays the grid swaths relevant to the grid collection. Image file or satellite background imagery would be displayed if being used with the grid positioned accordingly.
- **Section 3** - reference line commands are here and position your grid to the relevant background that you may be using.
- **Section 4** - grid setting controls, size, spacing and flip control are here.

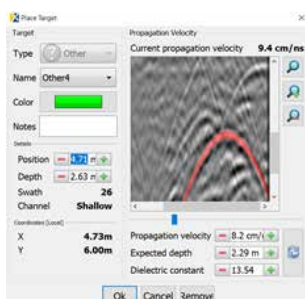


The collection widow is basically the same for both collection modes and will look something like this below;



The data is from the Leica Geosystems test site in Stoke. You can see the 'world map' on the left and both radar channels are visible on the right. Target selection has been made through the swaths, their positions plotted and relevant target lines drawn in the 'world map.' All targets picked are listed in the far right panel and are fully editable.

By selecting the target selection button, you get control of the on screen radar channels and can select your chosen hyperbola. This then opens the following window;



In this window you can adjust the dielectric constant / propagation velocity and perform a hyperbola fit. To achieve this, fit the red guideline by using the slider, the position and depth feature, and then move the guideline up and down or left to right for accurate fitting. You can also type in values if you know them. Assign target names and colours here, too, for utility designation.

No in depth stuff now, just a quick look at some of the features. Once you are collecting data and marking targets, the next step is reporting and exporting. These features are found in the main toolbar and include various exports.

- Report mode outputs a pdf report, two modes are available and are fully editable.
- Export options are shown below;



That's a wrap for the Leica DS2000, there's more of course there is.



IDS STREAM-C

The IDS Stream C system uses 32 antennas in one array housing and it has a big footprint. The system also uses antennas with two polarisations...that word again, I told you it's important. So, of the 32 antennas, nine are horizontal (HH) and 23 are vertical (VV) and are spaced really close together. The consequence of this is that the IDS Stream C can collect and process scan data and assemble it live in a 3D format, yes live 3D mapping. It has a central frequency of 600Mhz across the array so ground conditions dependant, 2.5m can be achieved with great results. It can even be towed behind a vehicle, if that's not your thing then there is motor assistance depending on the model chosen. Positioning again is fully supported and the way to go to if I'm honest with lots of options. Ideally this is a data collection tool and all the data should be processed ... IDS GRED HD time. If you're moving up to this from the Leica DS2000 then the operating system is going to be very easy to use as it is very, very similar to the IDS Unnext software you will be familiar with. Yes there are a few things that are different, but easy enough to get along with.

Leica Geosystems Detection Campus supports training for all the GPR systems and software within the Hexagon portfolio. Join me next time when we'll do processing.

Leica Geosystems – when it has to be right

Revolutionising the world of measurement and survey for 200 years, Leica Geosystems, part of Hexagon, creates complete solutions for professionals across the planet. Known for premium products and innovative solution development, professionals in a diverse mix of industries, such as aerospace and defence, safety and security, construction, and manufacturing, trust Leica Geosystems for all their geospatial needs. With precise and accurate instruments, sophisticated software, and trusted services, Leica Geosystems delivers value every day to those shaping the future of our world.

Hexagon is a global leader in sensor, software and autonomous solutions. We are putting data to work to boost efficiency, productivity, and quality across industrial, manufacturing, infrastructure, safety, and mobility applications.

Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous – ensuring a scalable, sustainable future.

Hexagon (Nasdaq Stockholm: HEXA B) has approximately 20,000 employees in 50 countries and net sales of approximately 3.8bn EUR. Learn more at hexagon.com and follow us @HexagonAB.



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